Calibration & Recalibration of Force & Load Sensors

The presentation with begin at 11 AM EST

Bart Morrick

Organizational Information

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- If you have additional technical questions, feel free to contact our technical support team at support@usa.hbm.com

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Bart Morrick

- **Application Engineer with HBK**
- **Joined HBK in 1985**
- **Has 30+ years of sensor experience**
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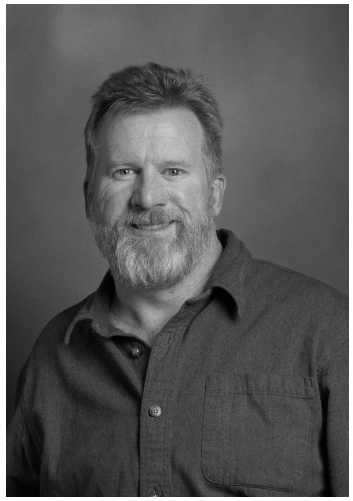

Agenda

1. Introduction: Why calibration is important
2. Calibration of your load & force cells
3. Reference sensors
4. Reference amplifiers
5. Reference bridge simulators
6. Conclusion
7. Q & A

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Introduction: Why is calibration 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

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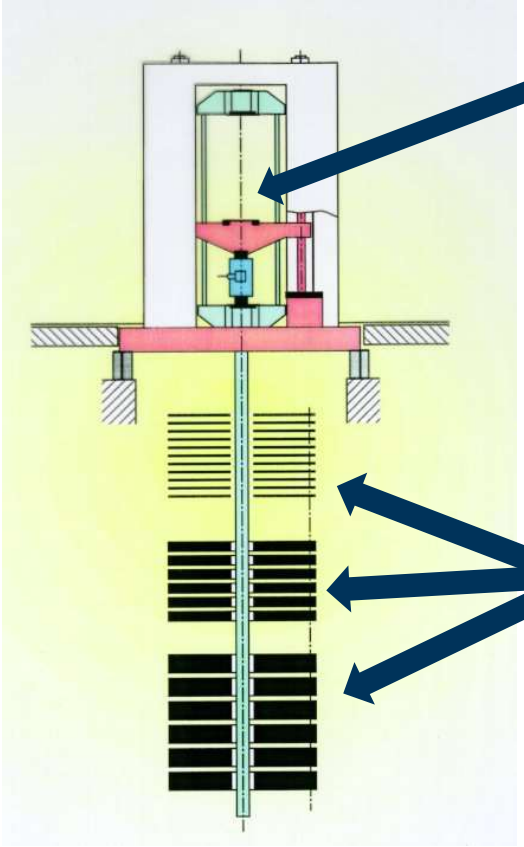
Introduction: Why calibration is important?

- Development Center
- Production facilities

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 %**

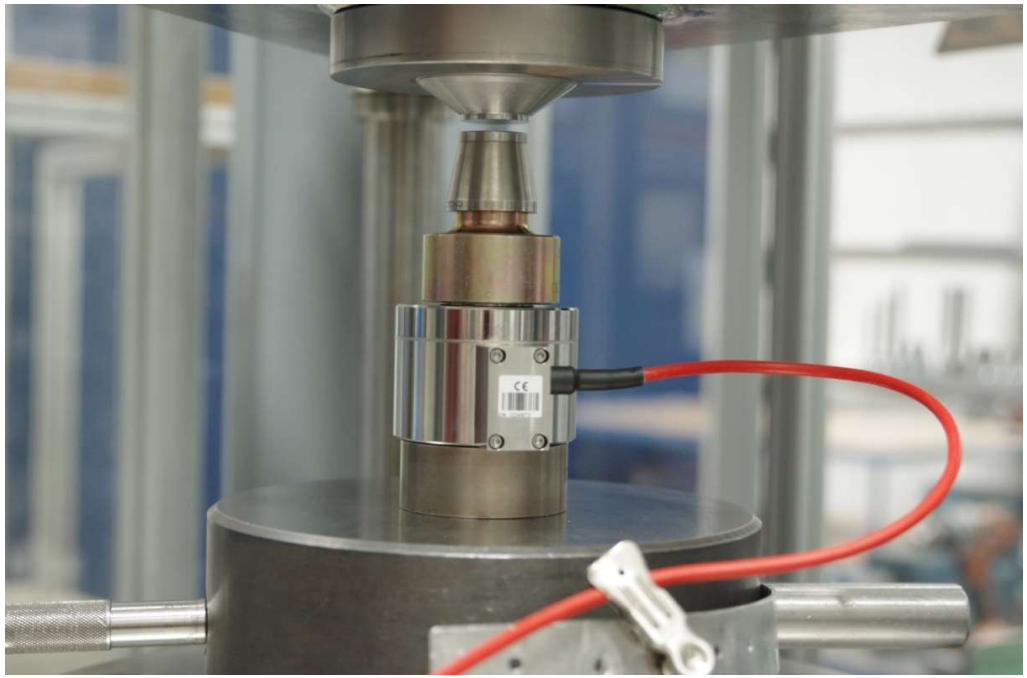
Relative to the force measured; For k=2

Calibration Lab

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



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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

Calibration of your load cells

Method one:

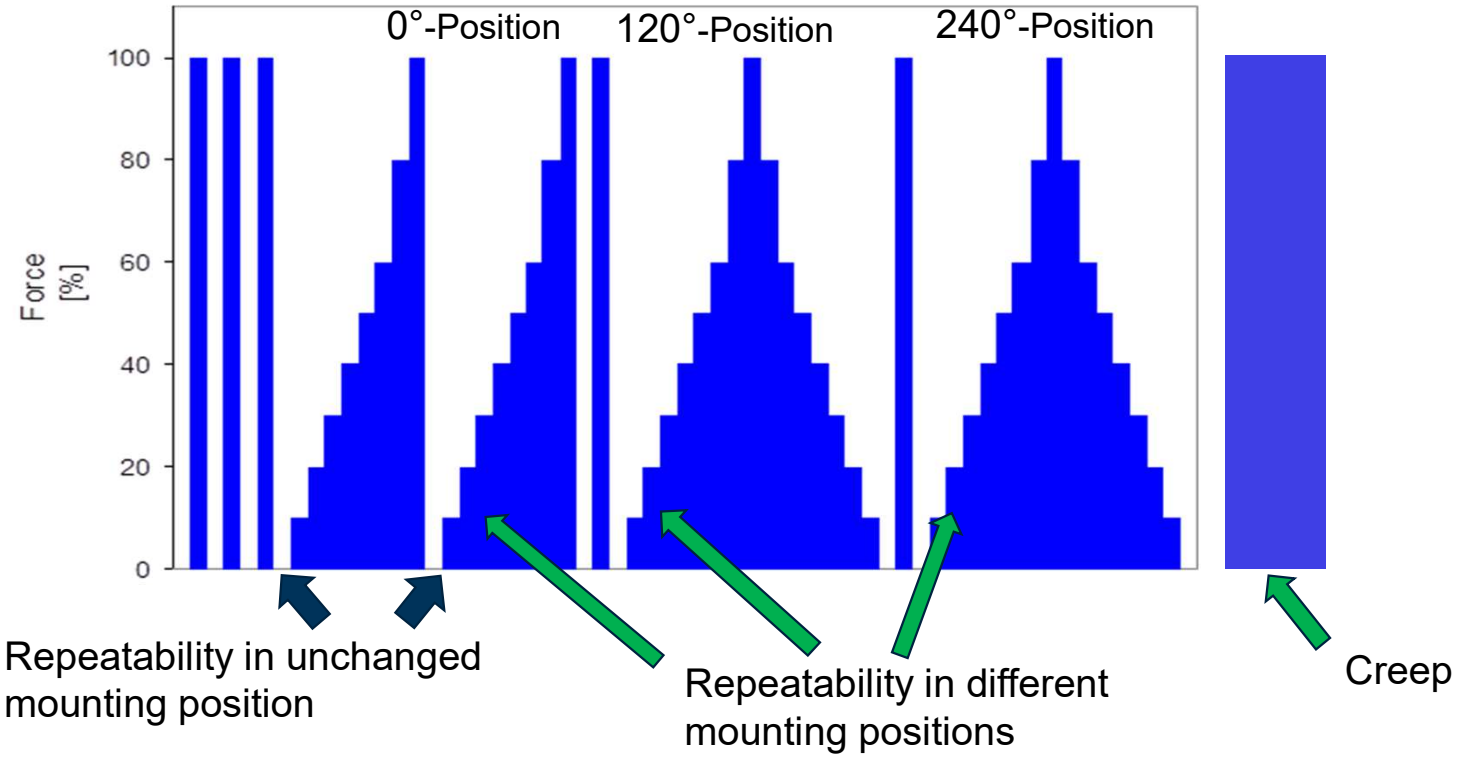
Send your load cells for calibration to a accredited laboratory (such as HBK)

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

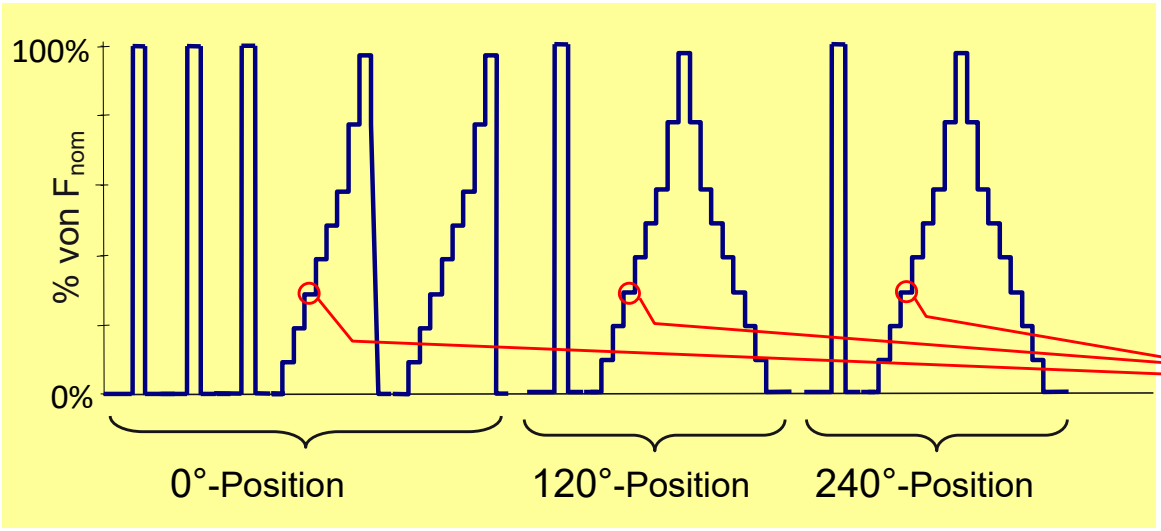
Force	Best measurement capability	
	tension	compression
2.5 N – 200 N	0.008 %	0.005 %
50 N – 2.5 kN	0.008 %	0.005 %
500 N – 25 kN	0.008 %	0.005 %
5 kN – 240 kN	0.01 %	0.01 %
50 kN – 1MN	0.02 % (500 kN)	0.01 %
100 kN – 5 MN	0.02 %	0.02 %

Calibration of your load cells: ISO376

Calibration according the ISO standard

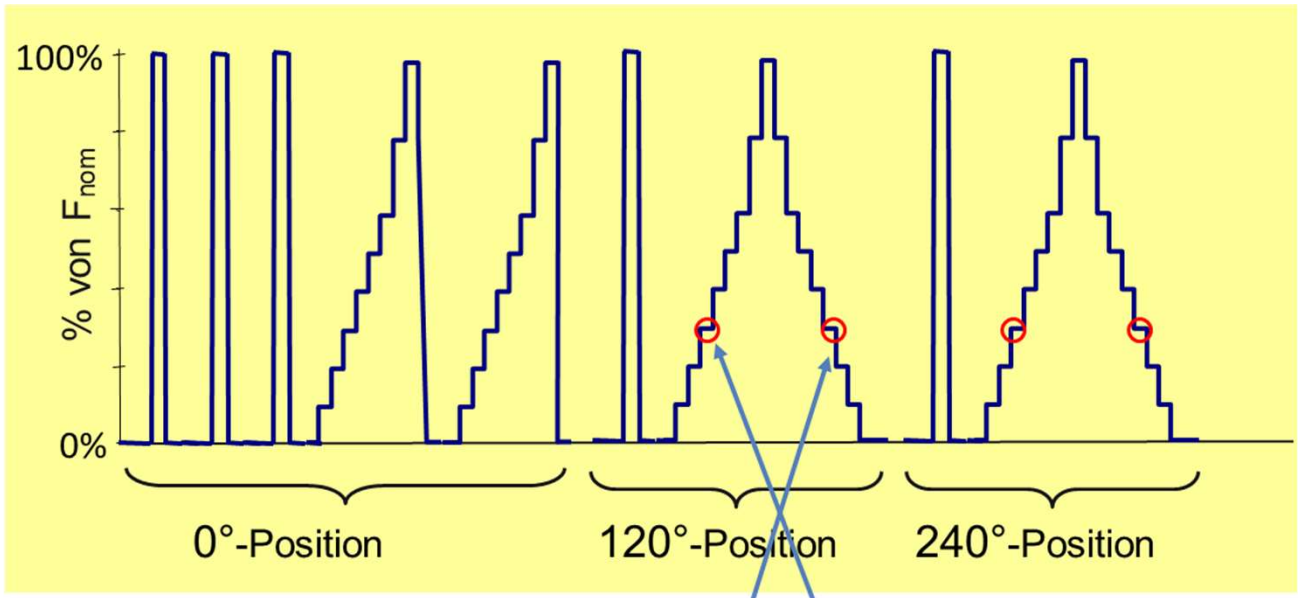


Calibration of your load cells: ISO376



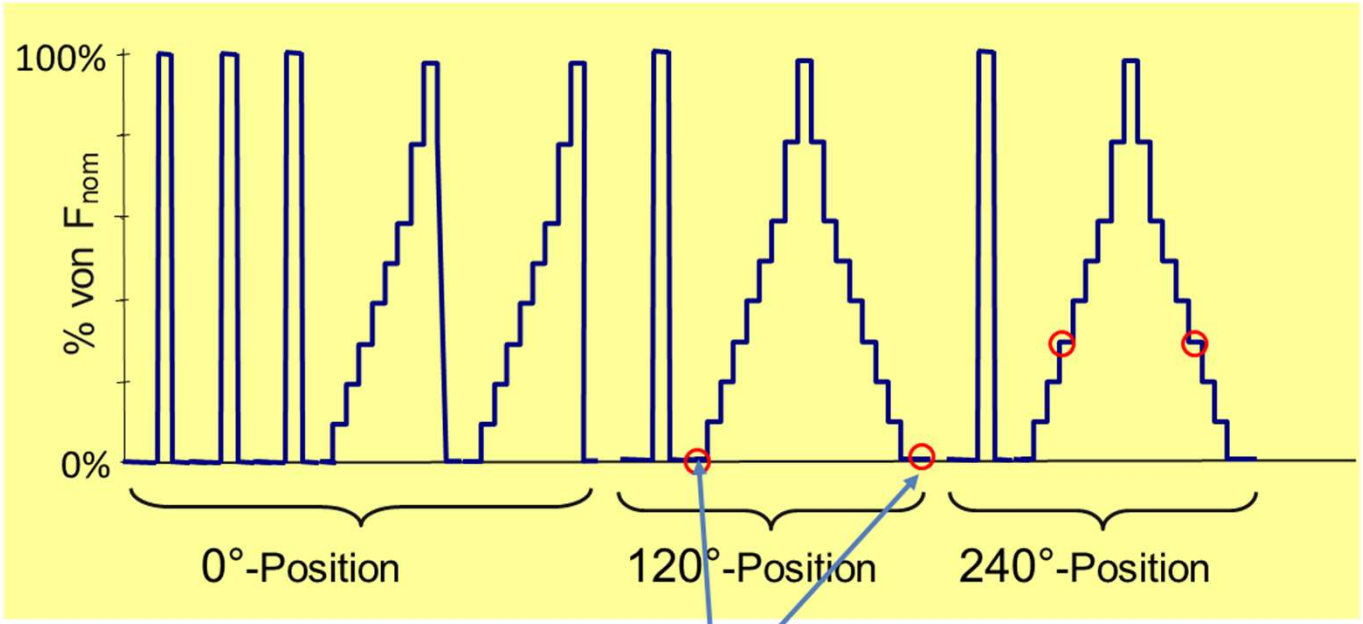
Three measurement values at one load

Calibration of your load cells: ISO376 - Hystersis



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

Calibration of your load cells: ISO376 – Zero Return

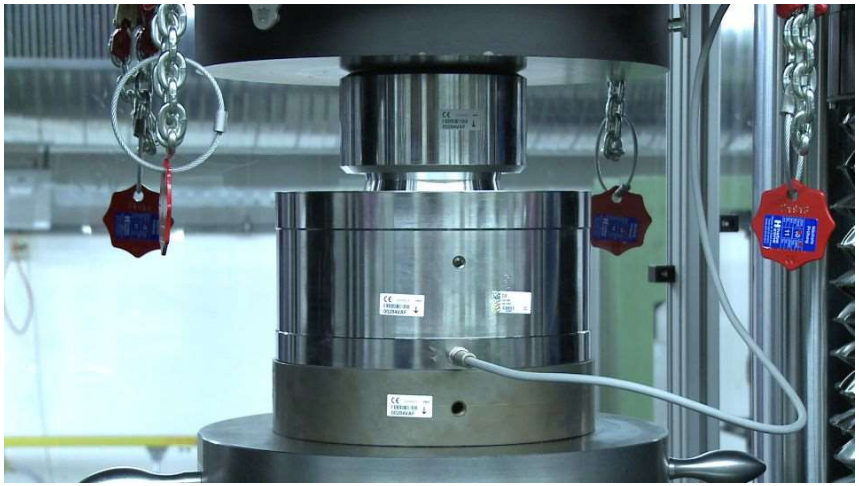


$$f_0 = \frac{i_f - i_0}{X_N}$$

Calibration of your load cells:

Results of an ISO376 calibration:

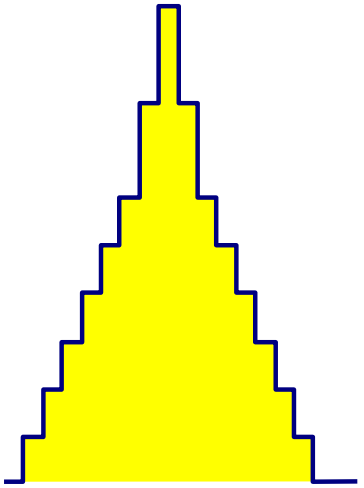
- Sensitivity at different load steps
- Cubic approximation of the sensitivity
- Uncertainty of the load cell for different use ***cases***



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

Calibration of your load cells: DKD R3-3 Standard

- 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: Measurement Chain

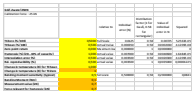
Class	Relative error of the force-proving instrument %						Expanded uncertainty of applied calibration force (95 % level of confidence) %
	of reproducibility b	of repeatability b'	of interpolation f_c	of zero f_0	of reversibility v	of creep c	
00	0,05	0,025	±0,025	±0,012	0,07	0,025	±0,01
0,5	0,10	0,05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

Calibrating the entire measurement chain

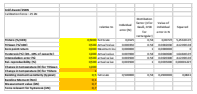
- Sensor
- Cabling
- Amplifier

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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Reference load cells

Requirements tied to transfer standards:

- Excellent repeatability in different mounting positions
- 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

Reference load cells

10MN, CL „00“

Standard load cells for forces up to 5 MN

Reference load cells

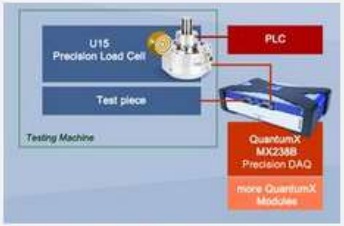
- Fulfill the requirements ISO376 standard between 10 % and 100 % of capacity
- TCZero: Just 75 ppm/10k!
- Output: > 2 mV/V for all capacities up to 10 kN, > 4 mV/V for all capacities larger than 10 KN

2.5 kN … 1 MN

2.5 kN … 2.5 MN

Reference Measuring Amplifiers

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 U15:

- Economical pricing but advanced precision
- Input ranges of the amplifier fit to the output signal of the U15
- Measuring chain calibration for optimized results
- 225 Hz technology- traceability on an international scale

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Precision Measuring Amplifiers

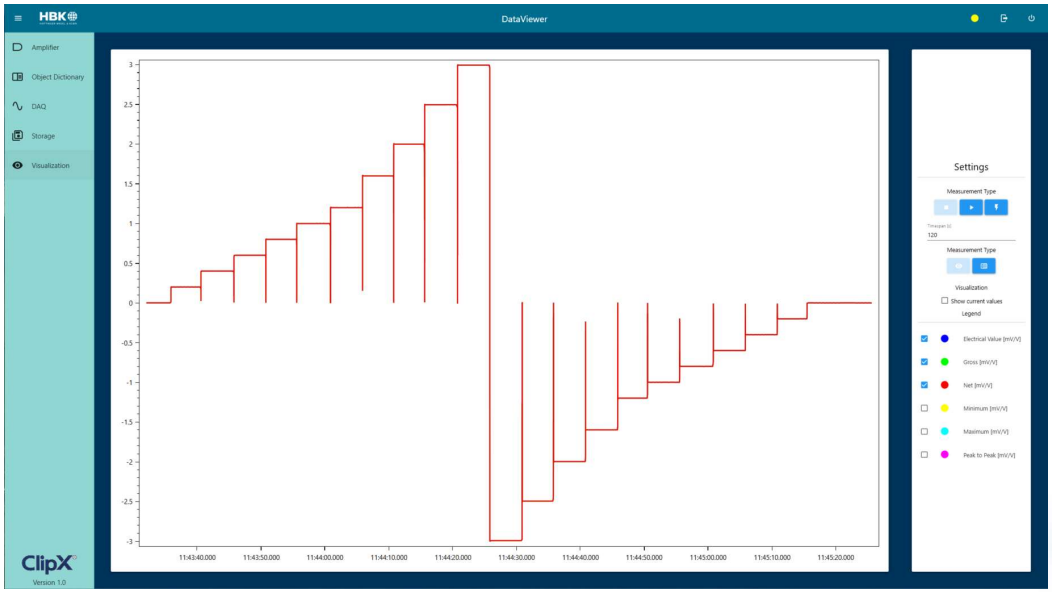
$$c = \sqrt{a^2 + b^2}$$

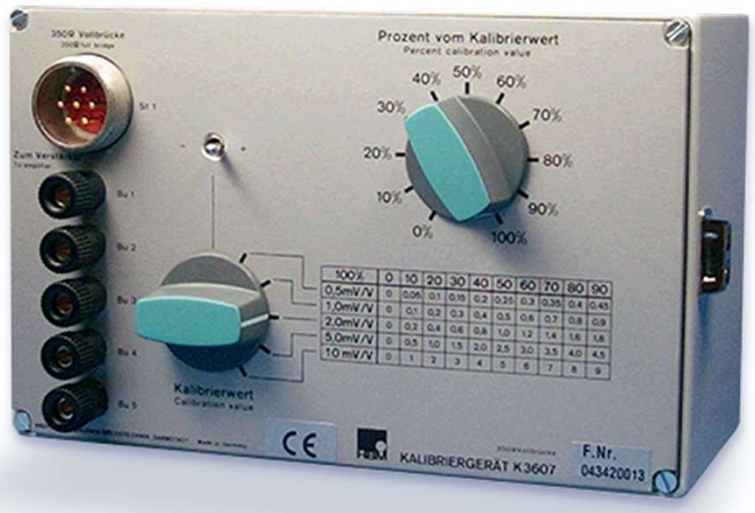
Thereof c = total accuracy of measuring chain
a = accuracy of transducer (e.g. force or torque)
b = accuracy of precision instrument

And if b = 0, what is about true, so it leads to

$$c = a$$

Reference Bridge Calibration Units





- Highly precise resistors
- Excellent zero point stability
- Doesn’t require you to place forces on sensors
- DC or 225 Hz technology- traceability on an international scale

Conclusion

- Introduction: Why calibration is important
- Calibration of your load & force cells
- Reference sensors
- Reference amplifiers
- Reference bridge simulators

Questions?

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Thank You

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