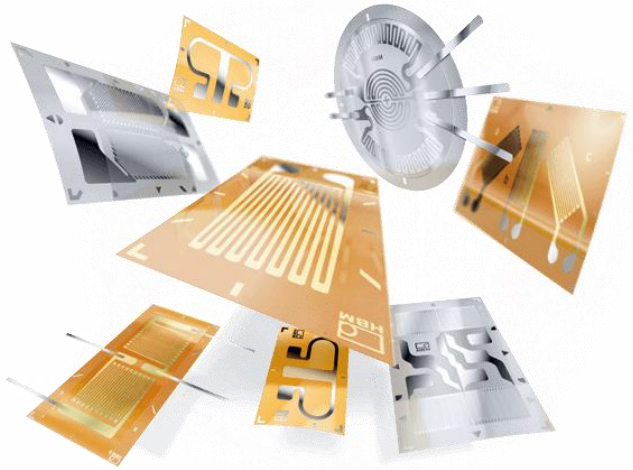
Building sensors based on strain gauge technology

HOW TO CHOOSE THE RIGHT STRAIN GAUGE?

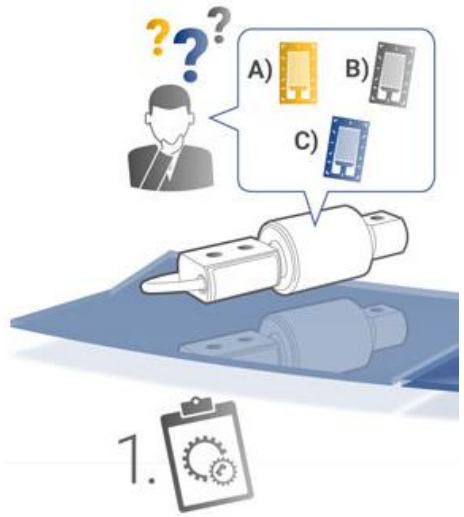


Malte Grieme

Agenda

1. Brief introduction to strain gauges in sensor construction
2. Which measuring grid foil makes sense for my application?
3. Learn how to control the creep of your sensor with proper selection of the creep adjustment
4. What possibilities are there to compensate for temperature-related measurement errors?

Strain gauges in sensor construction - applications



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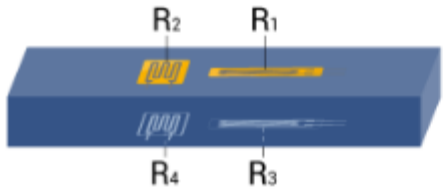
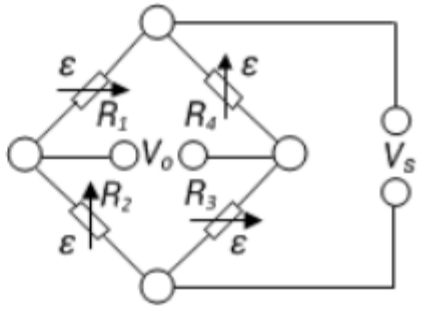
Strain gauges in sensor construction – working priciple





- measurement on a tension/ compression bar.
- Four active strain gauges, two of them rotated by 90°

✓Normal strain is measured independently of bending strain (bending is excluded)

✓Temperature effects are well compensated

✓High output signal

➢ It is all about symmetry

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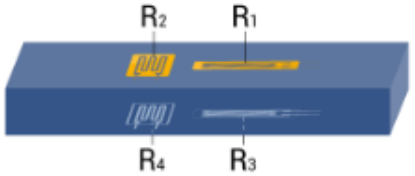
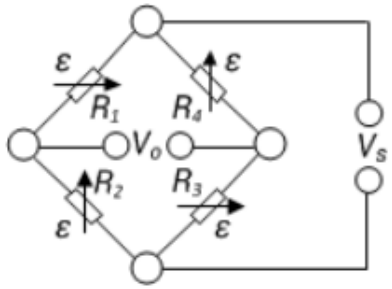
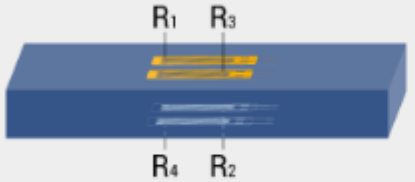
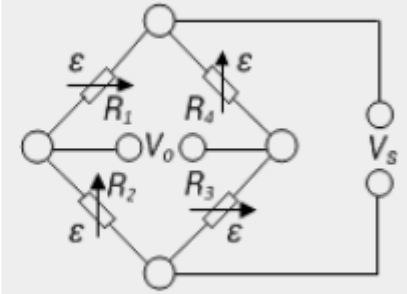
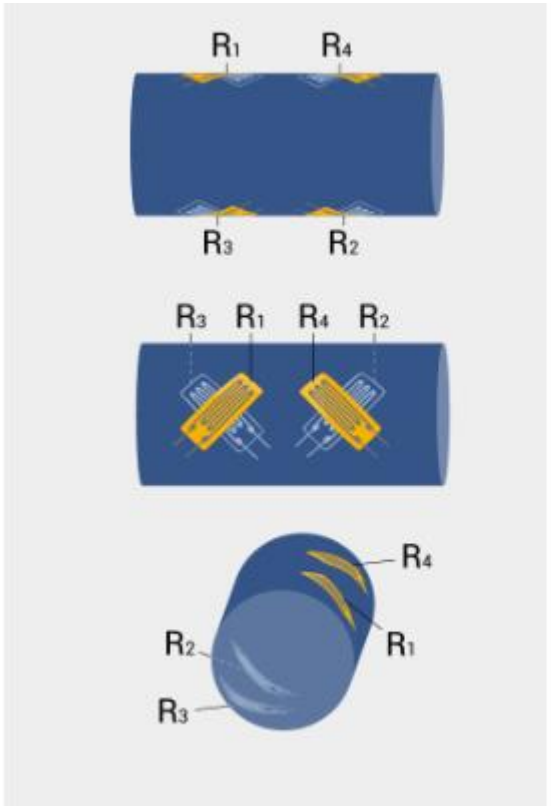
Strain gauges in sensor construction – working priciple

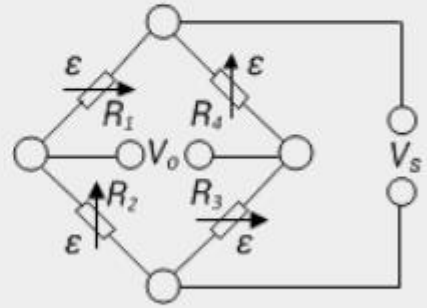












➢ https://www.hbm.com/en/7163/wheatstone-bridge-circuit/

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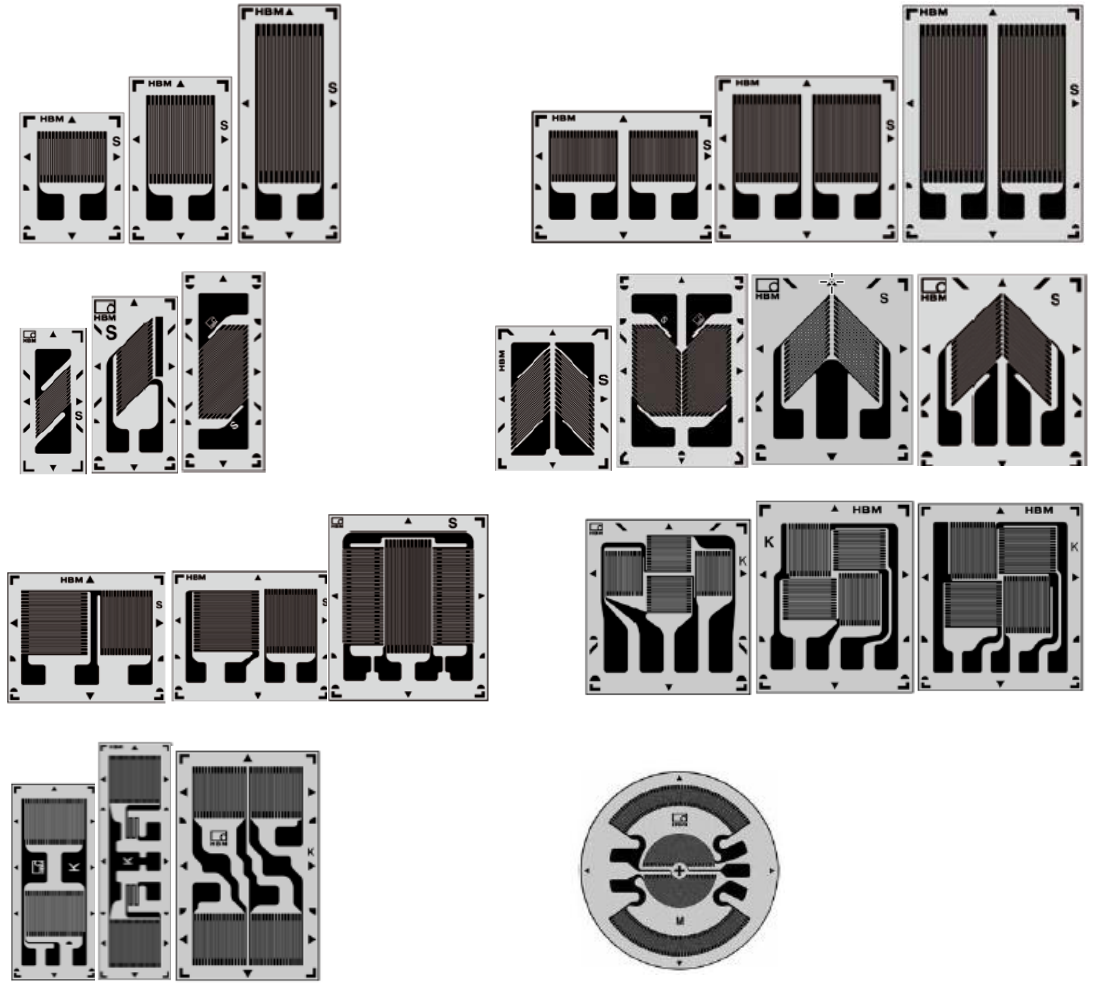
Strain gauges in sensor construction - geometry

- Once the measuring principle is defined, the appropriate design must be selected. Key parameters:
  - Alignment of the grids
  - Size of the grids
  - Size of the SG carrier
  - Interconnection of the grids
  - Options



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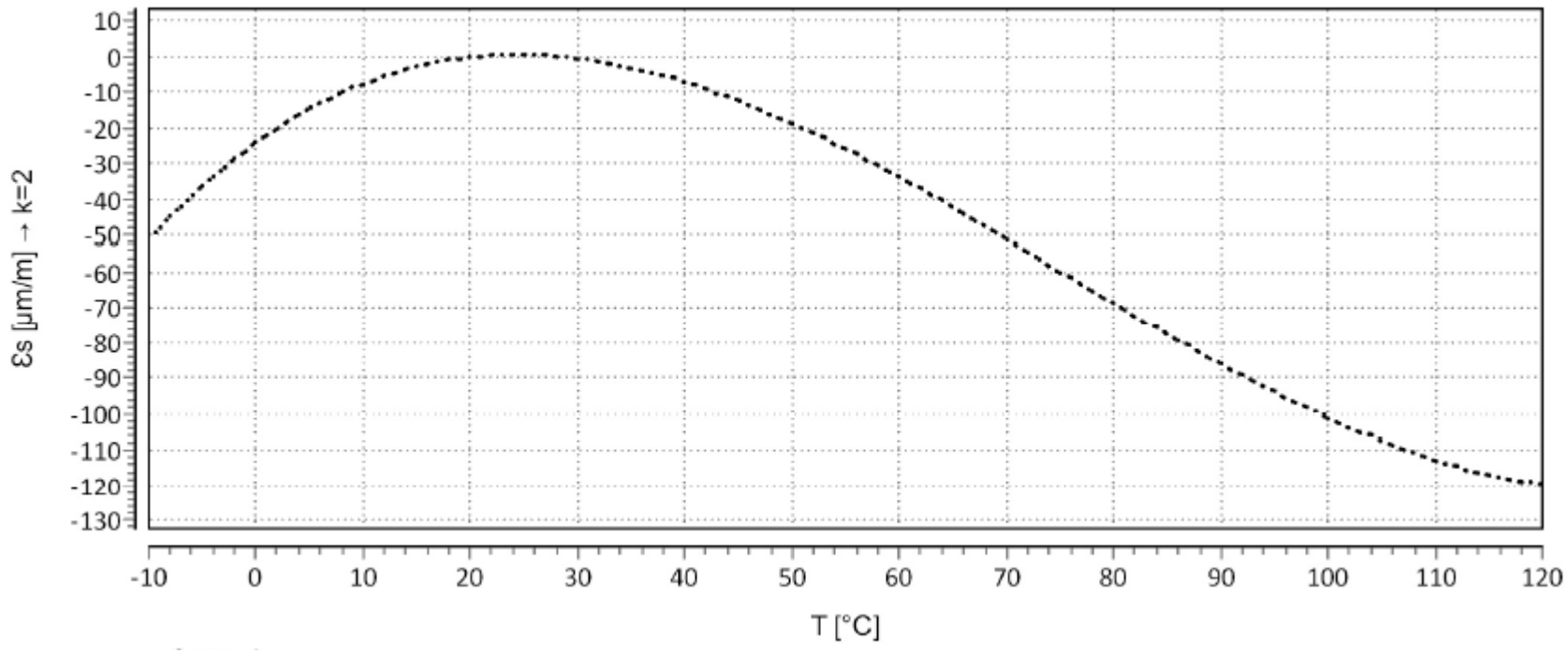
1. Brief introduction to strain gauges in sensor construction
2. Which measuring grid foil makes sense for my application?

Which measuring grid foil makes sense for my application?

- Temperature adaption:
  - Steel
  - Aluminum
  - Customized
- Foil material
  - Constantan
  - Modco (Karma)



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Which measuring grid foil makes sense for my application?

Constantan

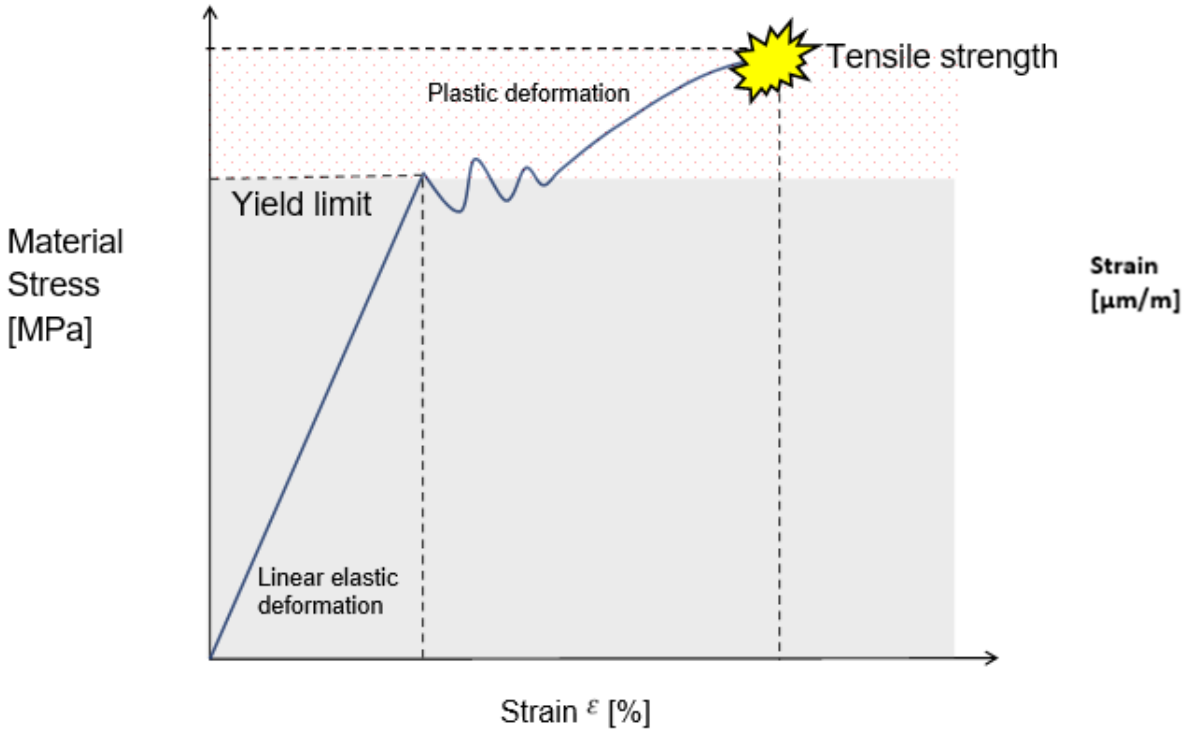
- Alloy generally consisting of copper, nickel and manganese
- k-factor: ~2
- Fatigue strength: ±1.200 µm/m @ >10^7 cycles

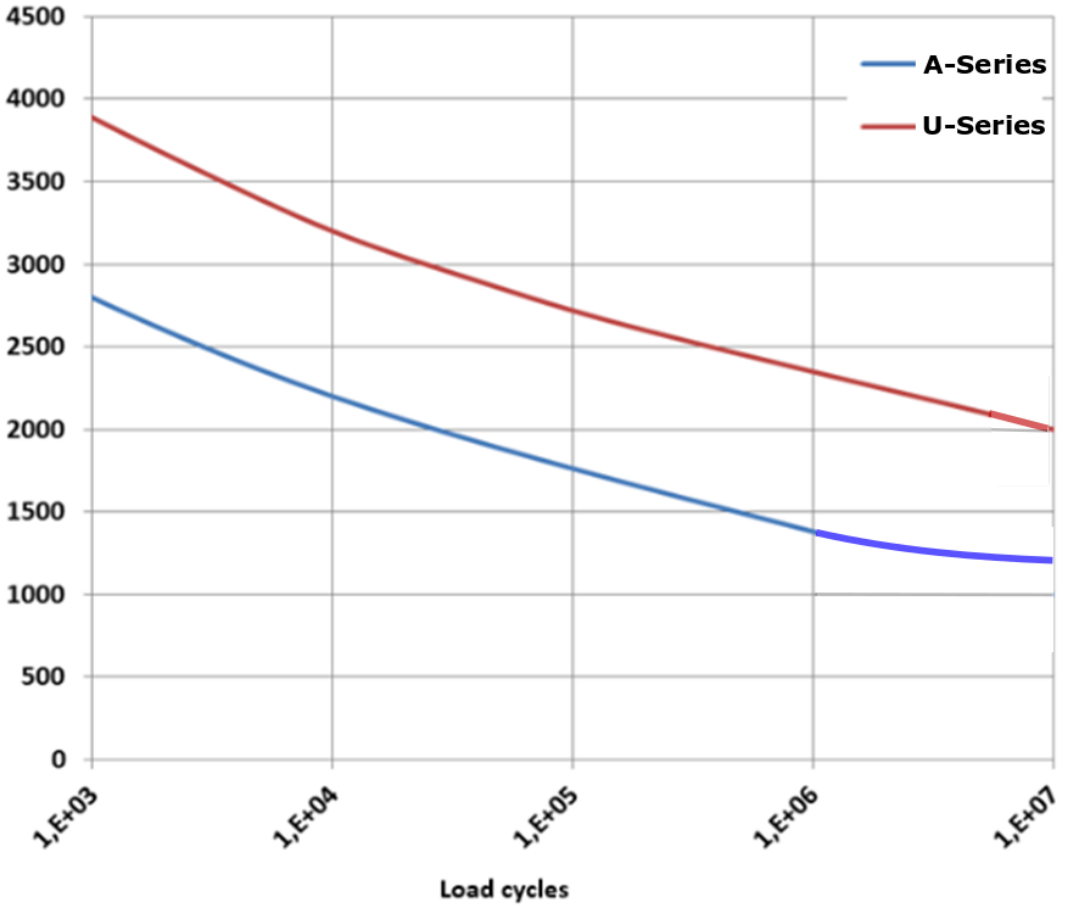
Modco (Karma)

- Ni-Cr alloy
- k-factor: ~2.2
- Fatigue strength: ±2.000 µm/m @ >10^7 cycles

- Modulus compensated
- Higher specific resistance
- Higher temperature range

Which measuring grid foil makes sense for my application?





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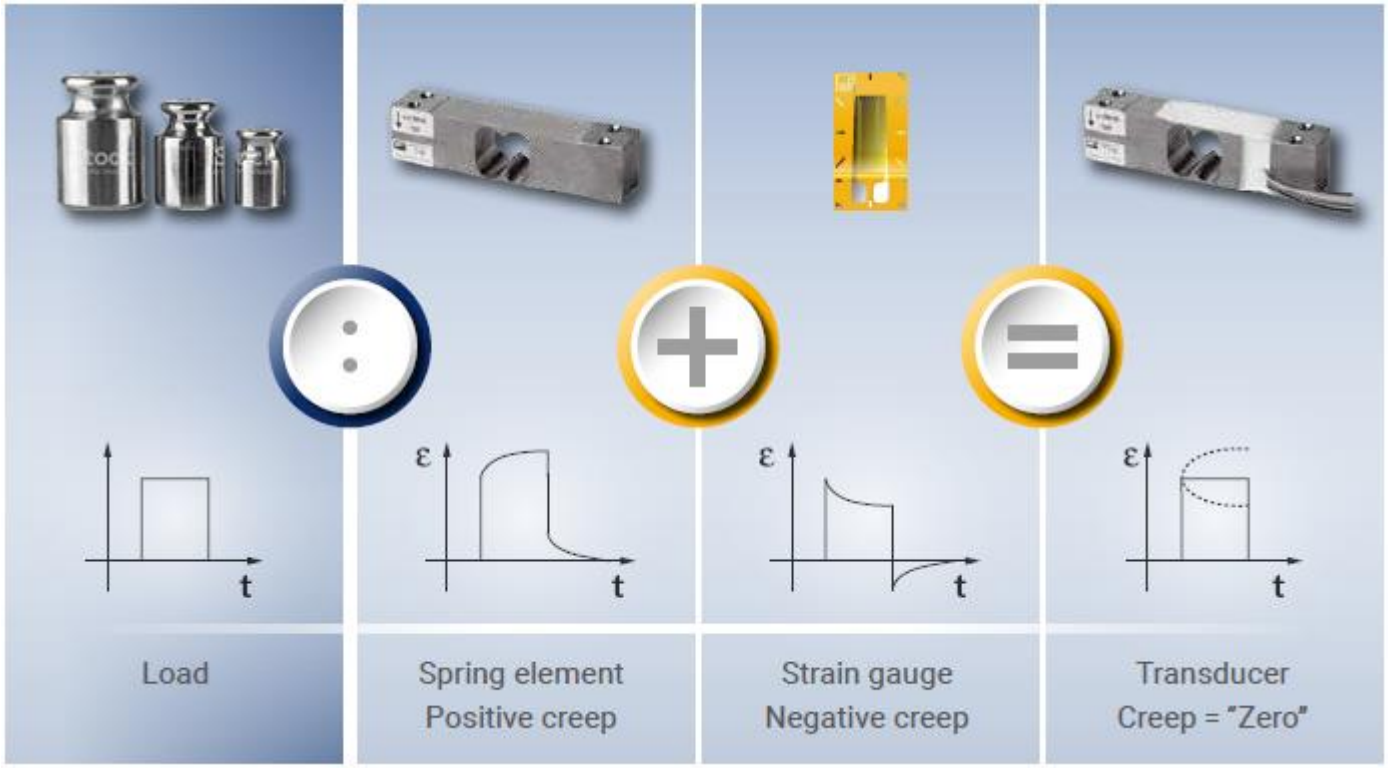
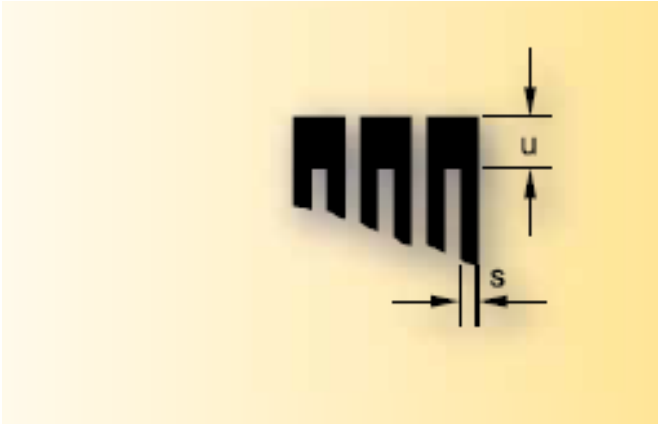
Sensor creep





A: u = 1 s	M: u = 7 s
C: u = 2 s	O: u = 8 s
E: u = 3 s	Q: u = 9 s
G: u = 4 s	S: u = 10 s
I: u = 5 s	U: u = 11 s
K: u = 6 s	W: u = 12 s

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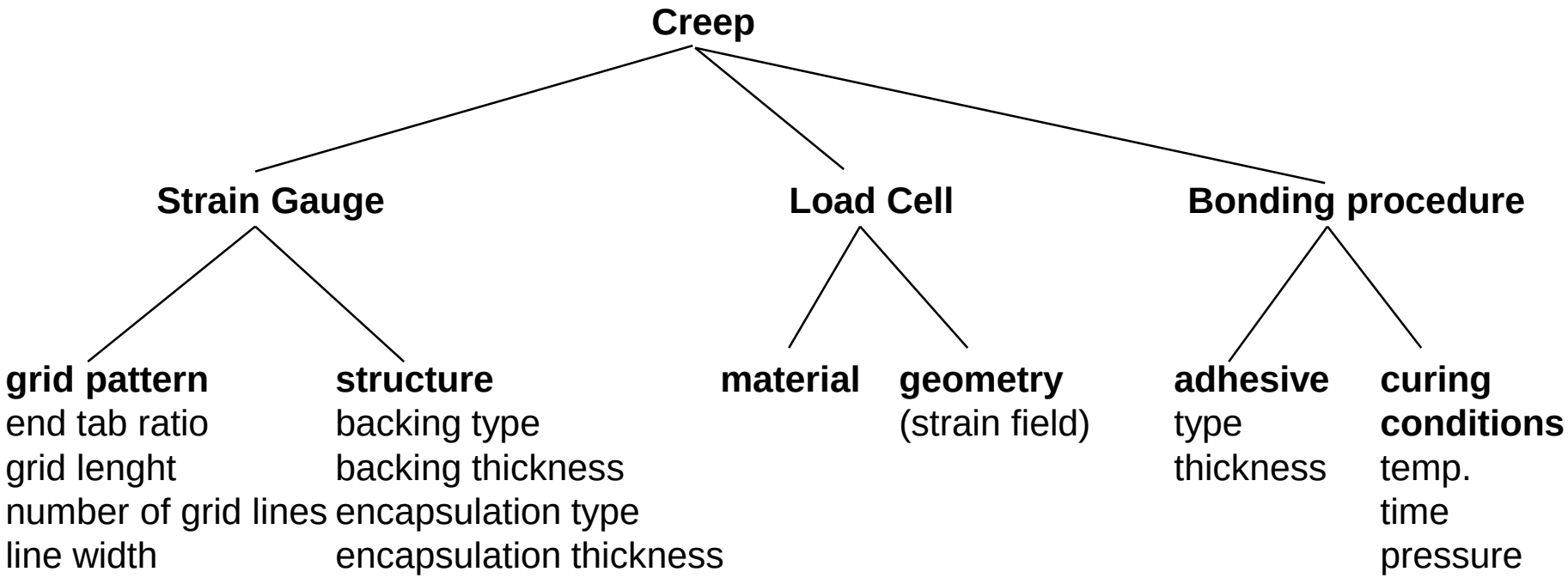
Sensor Creep



Conclusion:
The end tab ratio is one of many parameters, affecting creep. The effect of different end tab ratios on creep has to be evaluated experimentally, keeping all other parameters constant. Different sensors using SG´s with the same end tab ratio show not necessarily the same creep!

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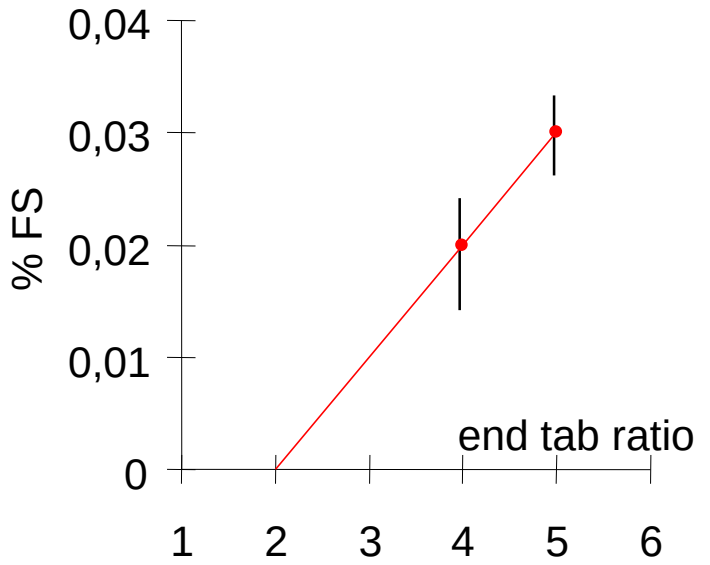
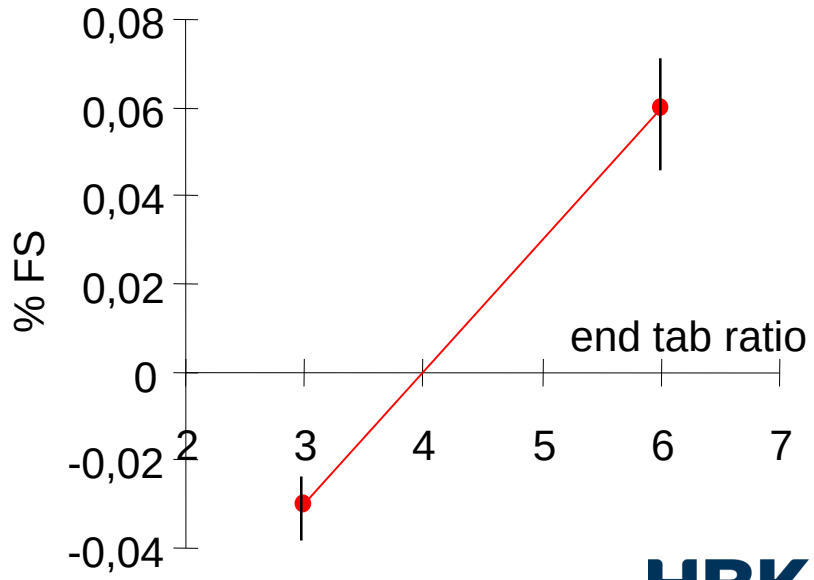
Sensor creep – experimental testing

- Choose the right SG (length, width, resistance....)
- From this particular SG minimum two end tab ratios are needed, e. g. u = 6s and u = 10s.
- Build up at least 5 sample sensors with the two differrent end tab ratios under the same conditions.
- Evaluate the test results by linear regression
- Derive the best end tab ratios by interpolation or extrapolation





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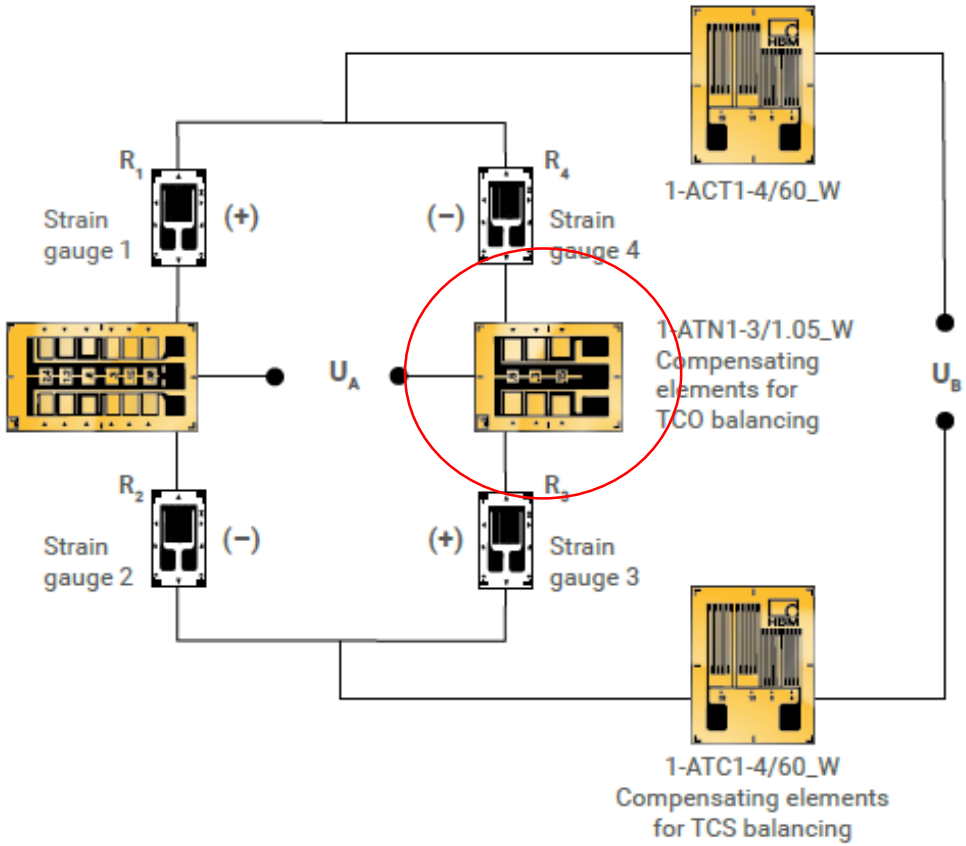
Temperature related measurement effects – TC0

TC0 occurs because of unsymmetric temperature dependent resistances within the four bridge arms:

- different length of connecting lines within the bridge
- different TCR of the grids

<u>Solution:</u>

- Compensation by introducing a temperature dependent resistance in the right bridge arm.



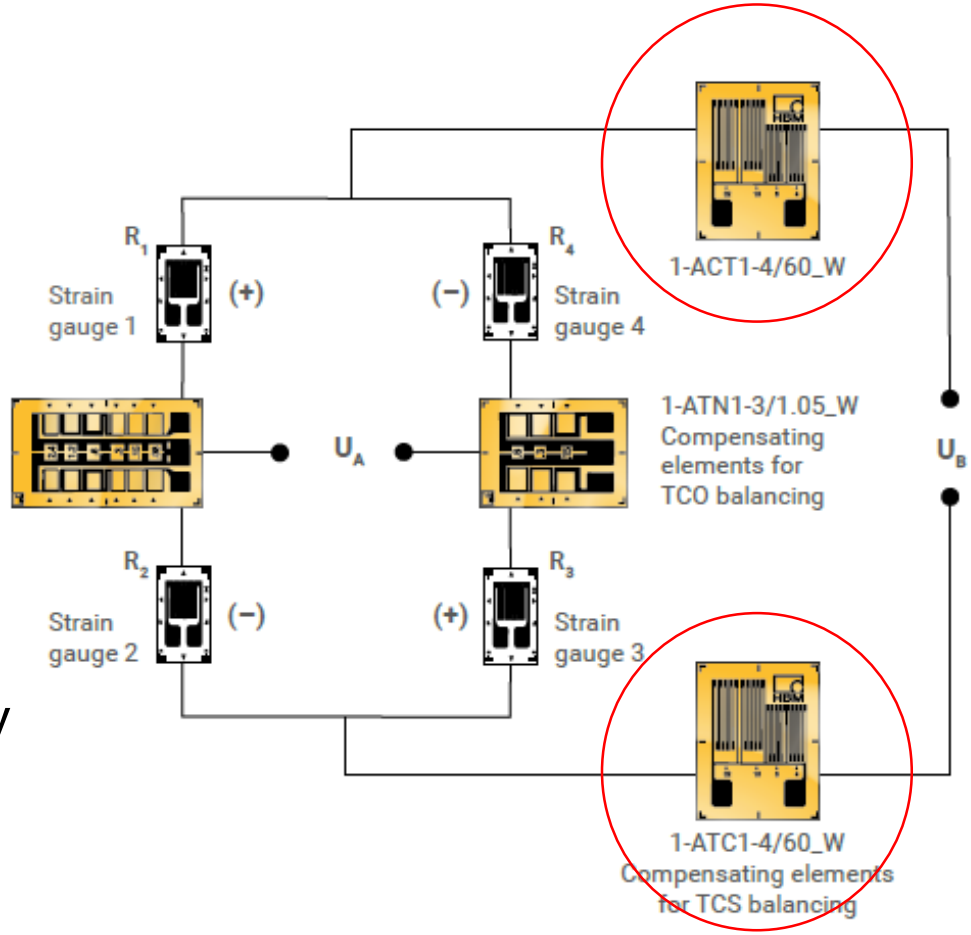
Temperature related measurement effects – TCS

TC-span occurs because of:

- temperature dependence of Youngs modulus of the sensor material
- temperature dependence of the gauge factor

<u>Solution:</u>

Compensation by introducing a temperature dependent resistance in the input line. That resistance reduces the effective excitation voltage over temperature in such a way that the increase of the sensors output caused by the change of Youngs modulus and the gauge factor with temperature is compensated. With increasing temperature the excitation voltage has to be lowered, because the output of the sensor is increasing (indirect proportional).



Further literature and help

- Online knowledge base „Strain Gauge Fundamentals“
  - https://www.hbm.com/en/7074/strain-gauge-fundamentals/

- The Route to Measurement Transducers: The Reference Book from HBM for you to Download
  - https://www.hbm.com/en/3736/tips-tricks-transducer-design/

- Catalog: Strain Gauges for Transducer Manufacturers
  - https://www.hbm.com/fileadmin/mediapool/hbmdoc/technical/S01266.pdf

Thank You