

Welcome to the webinar: “How to Avoid Typical Errors During Strain Gauge Installations”



WEBINAR

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Manuel Schultheiß

1. Overview of potential error sources in measurement chain
2. Typical error sources during strain gauge installations
3. Summary

The installation of electrical foil strain gauges can be time consuming and implies different potentials for installation errors.

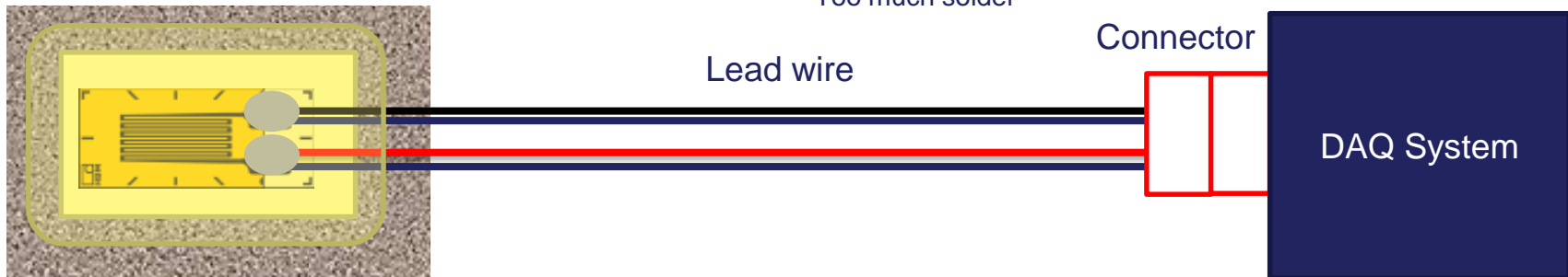


Each strain gauge specialist should consider the following tips how to maximize the quality of a strain gauge installation.

Typical sources for errors during strain gauge installation



- | | | | | | |
|---|---|---|---|--|---|
| <ul style="list-style-type: none"> • Wrong load case assumption • Select the wrong grid length • Inaccurate positioning of the gauge • Underestimation of mechanical strains/loads • Deviation of environmental conditions from product specifications (temperature, humidity) | <ul style="list-style-type: none"> • Damage the surface during position marking • Damage material by using too aggressive cleaning agents • Insufficient roughness of surface • Insufficient cleanliness of surface | <ul style="list-style-type: none"> • Wrong adhesive • Insufficient curing conditions (temperature, pressure) • Exceeding expiry date of adhesive | <ul style="list-style-type: none"> • Missing pretreatment of solder terminals • Wrong soldering temperature • Inaccurate soldering device • Missing knowledge/training • Too long soldering time • Too spiky soldering tip geometry • Contaminated solder tip • Too much solder | <ul style="list-style-type: none"> • Use of 2-wire technology by high thermal influence on lead wires • Damage during stripping • Missing/Insufficient strain relief on connector • Use of the wrong connector | <ul style="list-style-type: none"> • Insufficient protection • Use of not qualified covering agents • Mechanical influence by covering agent |
|---|---|---|---|--|---|

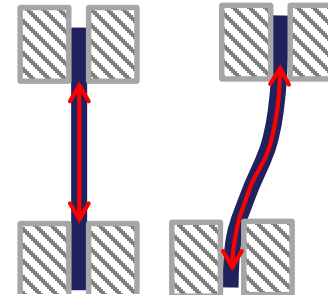
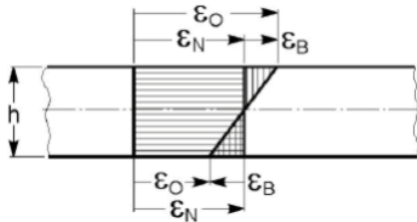


Typical sources of error during strain measurement set up



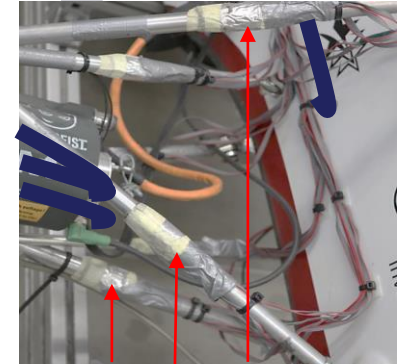
1. Wrong load case assumptions

- Example: Superposed bending effect on tension/compression bar



Theory:
only tension/compression

Reality:
tension/compression
+ bending

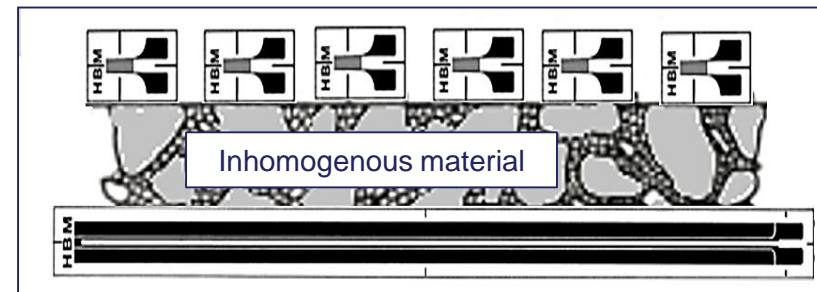


Strain gauges on tension/compression bar on suspension arm of formula car

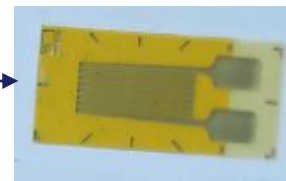
- Find the right gauge for load case (uniaxial, biaxial, 3-grid rosette...)

2. Wrong strain gauge setting on the component

- Select the correct grid length (5 x length of inhomogenous area)
- Correct alignment on surface



Tip: Use alignment marks on gauge



Typical sources of error during strain measurement set up

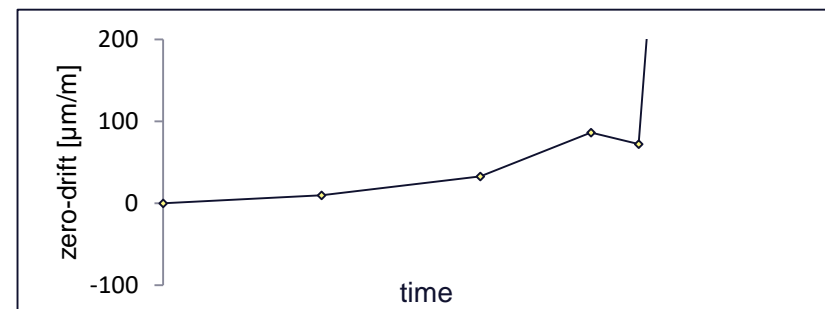
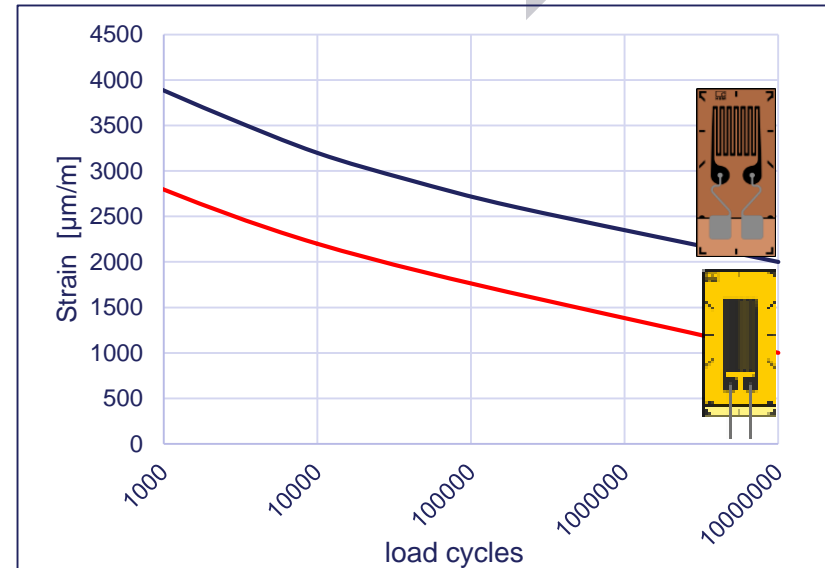


3. Take the wrong gauge for the real load case

- Metal foil strain gauges are limited in their fatigue behavior
- For high load fatigue tests M-Series gauges are recommended

4. Deviation of environmental conditions from product specifications (temperature, humidity)

- Exceeding temperature ranges of strain gauges will lead to delamination of gauge carrier and foil and will impact the measurement signal
- Exceeding the humidity specifications of adhesives can lead to moisture expansion of adhesive



Typical sources of error during surface preparation



1. Damaging the surface for strain gauge position marking

Ensure not to damage the surface (notch effect!)

2. Use of too aggressive cleaning agents on sensitive materials

(Composites, polymers...)

3. Use of not chemically pure cleaning agents (technically pure not sufficient)

RMS1 cleaning agent is perfect for most surfaces (Acetone + Isopropanol)

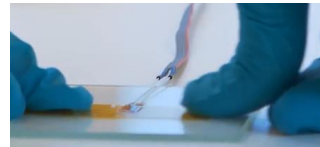
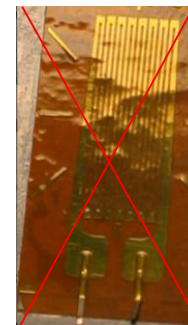
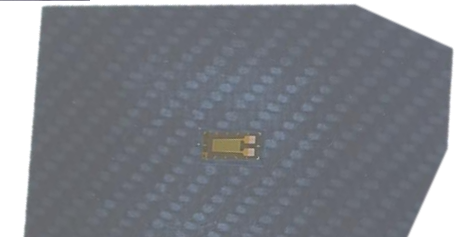
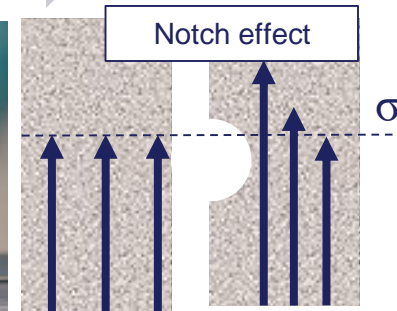
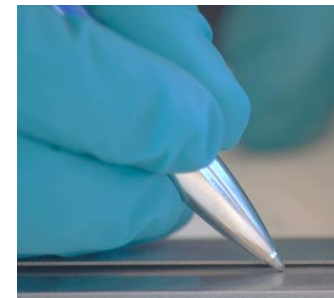
4. Insufficient roughness of the surface

Use grind paper with grain size of 220-300 (DIN 69100)

Do not damage deeper layers of composite materials

5. Insufficient cleanliness of surface

Cover prepared strain gauge installation spot with tape during longer breaks

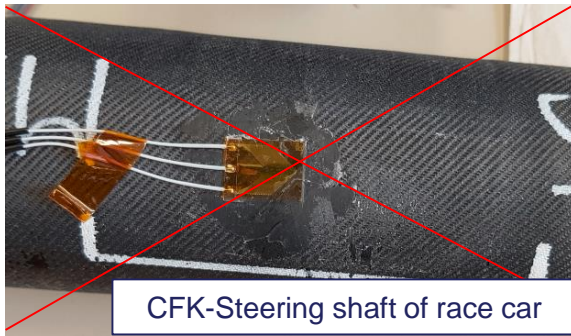


Professional strain gauge installation

Typical errors during bonding of strain gauges



1. Using the wrong adhesive



Smooth surfaces: Z70 (Cyanocrylate, Curing time: 1 min, cold curing)

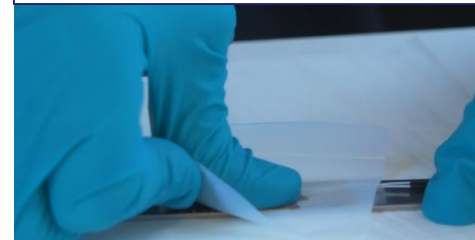
Rough/Porous surfaces: X60 (Methylmethacrylate, Curing time: 5-20 min, cold curing)

Transducers and high precision applications = Hot curing adhesives (P250, EP150, EP310N)

Experimental testing at moderate temperature = Cold curing adhesives (Z70, X60, X280)



Keep gauge calm during curing!



$$MU = \sqrt{(FEModulus)^2 + (F\varphi)^2 + (FGagefactor)^2 + (FAmplifier)^2}$$

2. Wrong curing conditions (temperature, pressure, humidity)

E.g. Z70 quick curing adhesive: Ensure relative air humidity of 40-70% and temperatures around 20°C for best results

3. Exceeding expiry date of adhesive

Typical errors during soldering of strain gauges



1. **Missing Pretreatment of solder terminals:** Clean solder tab and as free of oxide as possible

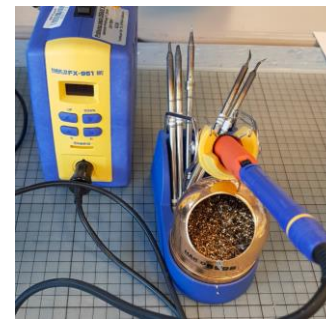
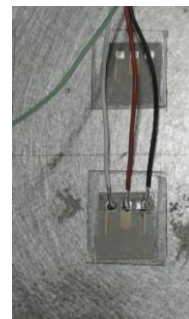
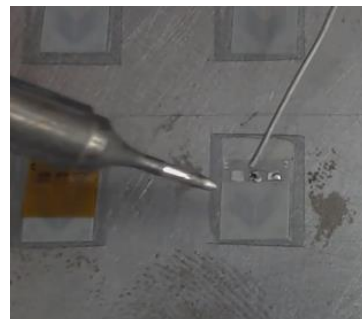
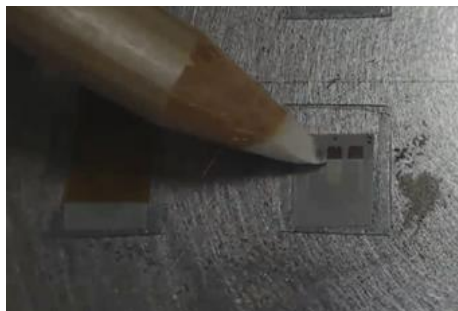
2. **Wrong soldering temperature:** Soldering temperature optimum 320-340°C on the soldering tip

3. **Unprofessional Soldering device:** Ideally use a **temperature-controlled** soldering station. Ensure right temperature on tip!

Good experiences with devices from HAKO FX951..., Weller WSM 1C

4. **Too long soldering time:** Should be as **brief** as possible; avoid soldering multiple times (< 1 s), Use flux (optional, if not already in solder) Solder recommended for standard applications (1-LOT-LF, Sn95,5Ag4Cu1) For special applications use special solders

5. **Personal knowledge/training:** Take your time and get a feeling for the solder behavior. Or visit HBM Academy



Typical errors during soldering of strain gauges



6. Wrong solder tip: Use a tip with a shape suitable for the solder pad

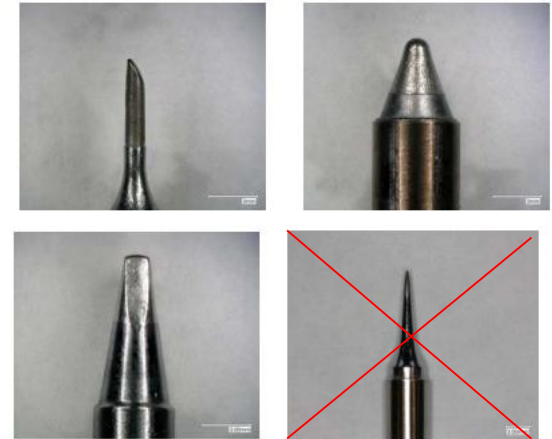
Note: tips wear out more quickly because of increased tin content in the solder and higher solder temperature! → **Reduce temperature** during longer breaks;

7. Contaminated solder tip: Before use, tin the soldering tip **with fresh solder**; strip off the old solder

8. Don't use too much solder!! (Risk of cracking)

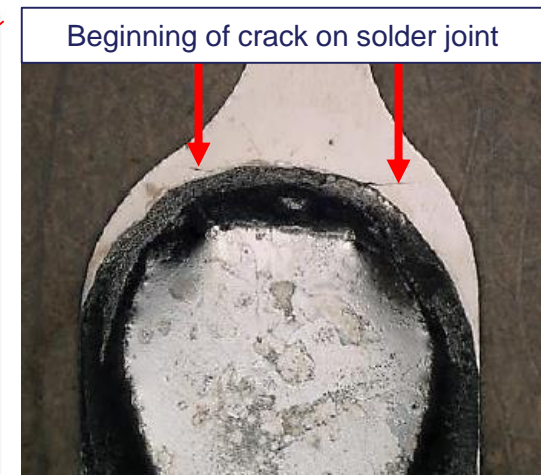
9. Remove solder flux

(Risk of corrosion and resistance drift)



Contaminated solder tip

| Solder joint | |
|--------------|-------------|
| Correct | Wrong |
| | |
| Meniscus | Solder dome |
| | |



Pre-wired gauges

Identify the right measurement setup

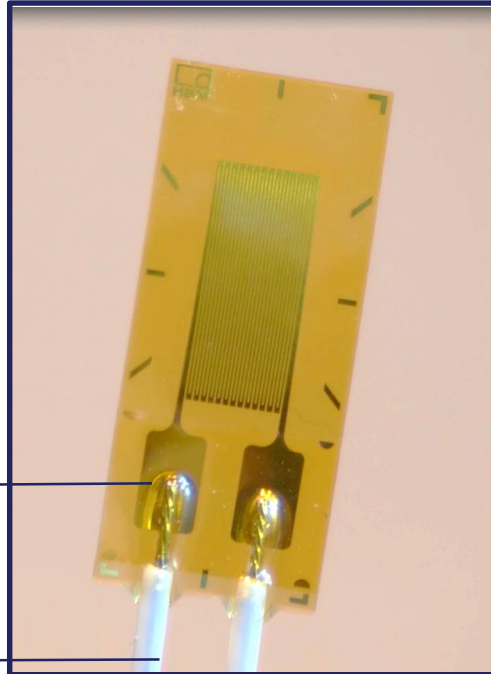
Surface preparation

Bonding

Soldering

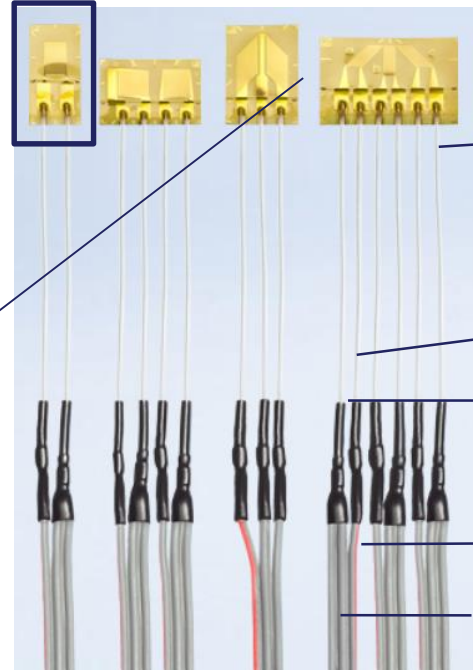
Wiring

Protection



Optimized soldering for high reliability

Fluoropolymer wire to allow easy bonding process



50mm fluoropolymer tubing

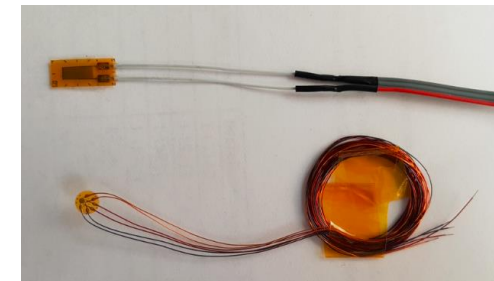
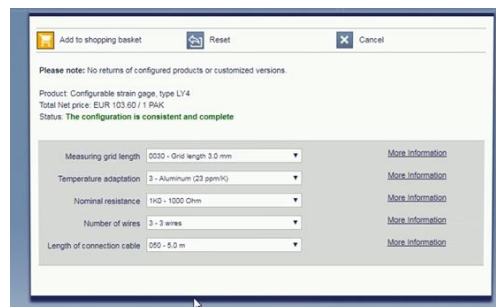
Heat shrink tubing

Crimped wires

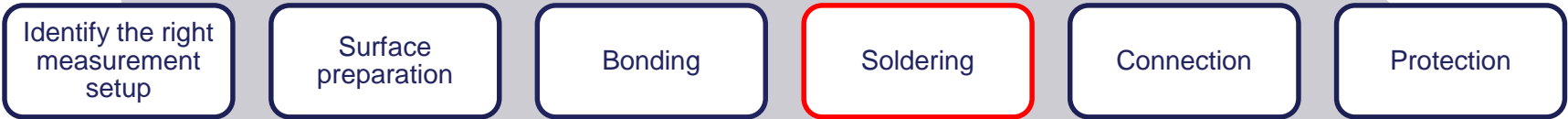
-40°C to +150° TPE cable

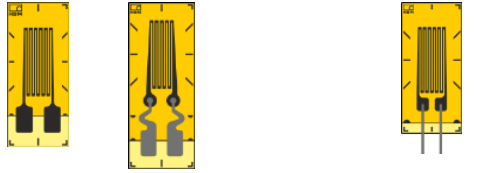

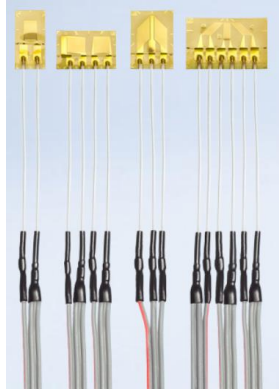
Individual length of TPE cable

Tip: Setup individual gauge in webshop configurator



Difference between conventional and pre-wired gauges



| Conventional foil strain gauges | Pre-wired foil strain gauges |
|--|--|
|  <p>Integrated solder tabs (with strain relief)</p> <p>copper leads</p> <p>+ Connection cable freely selectable + Highest fatigue life achievable by use of strain gauges with copper leads (stiff regions on the measurement grid are reduced)</p>  <p>4- and 6- wire PFA cable for strain gauge installations</p> <p>1-CABP1/20 1-CABP4/20</p> |  <p>+ Saves installation time + Reduced risk and high reliability because of high quality solder (even not so trained users can install the gauges) + No soldering on material required - Lower fatigue life than strain gauges with leads</p> |

Typical errors during connection of strain gauge



1. Using 2-wire technology without considering temperature effects on lead wire

Use: 3- or 4-wire technology for temperature based lead wire compensation

2. Damage lead wires during stripping process

Risk: Damage of sensitive strands

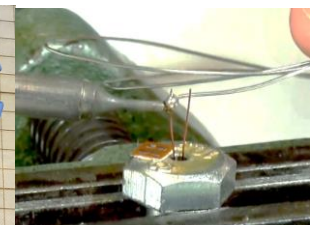
- Use professional stripping equipment
- Thin wires can be stripped thermally by soldering device
- Use of end sleeves recommended

3. Missing/Insufficient strain-relief on connector

- Ensure a really good strain relief on the connector



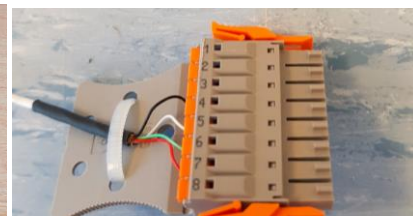
Professional stripping tool



Thermal stripping on a gauge integrated in a screw



End sleeves



Simple strain relief

Typical errors during connection of strain gauge



4. Use of the wrong connector:

A: For many durability tests especially in lab clamping connectors are sufficient.
An example is our QuantumX MX1615B module

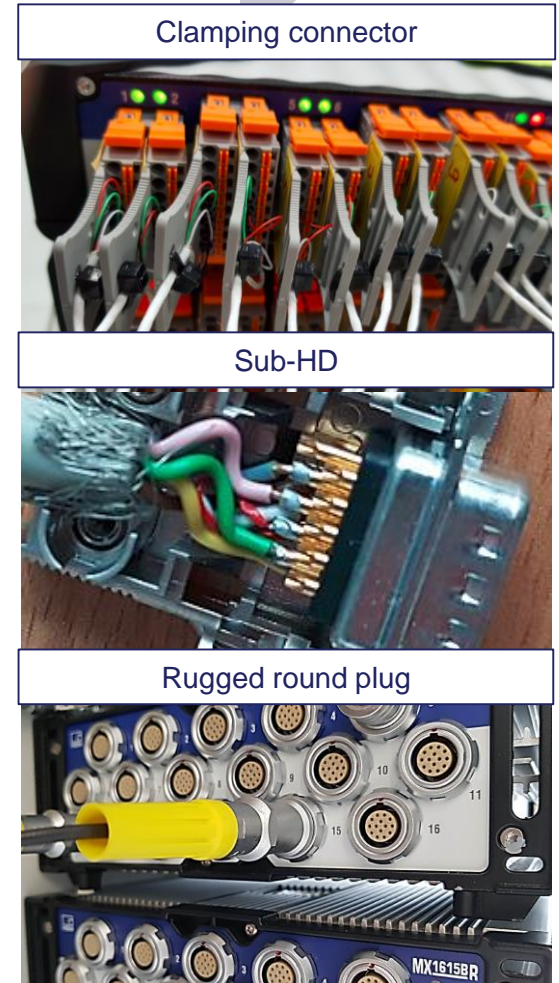
- + quick and easy installation
- + low cost
- + no soldering
- + reusability

B: Conventional connectors such as Sub-D (HD) require a soldering of the cable in the connector

- + high availability

C: For harsh environments a rugged round plug connector for MX1615B-R

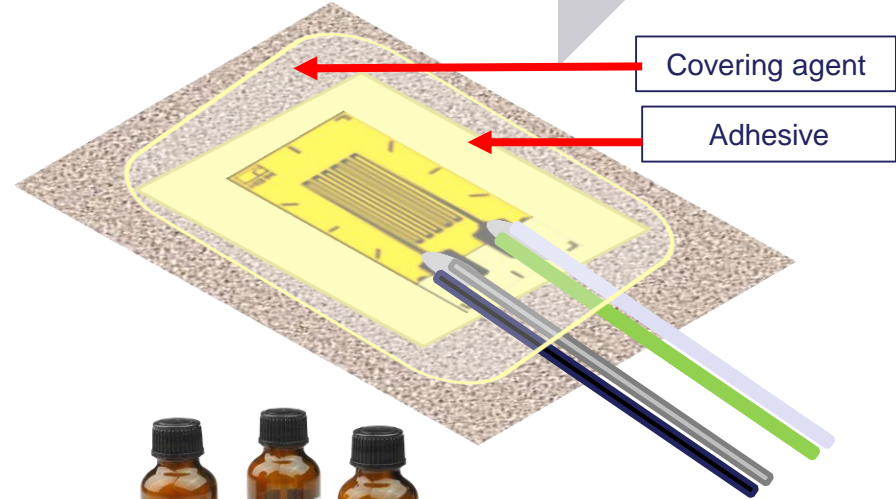
- + sealed (IP67)
- + ruggedized
- + high plug cycles





1. Insufficient protection

- Moisture causes corrosion
- Etching liquids can heavily damage measurement point
- Zero-point shift of measurement signal
- Sealing must cover all potential spots for ingress (no capillaries)
- Covering agents shall cover even the adhesive layers



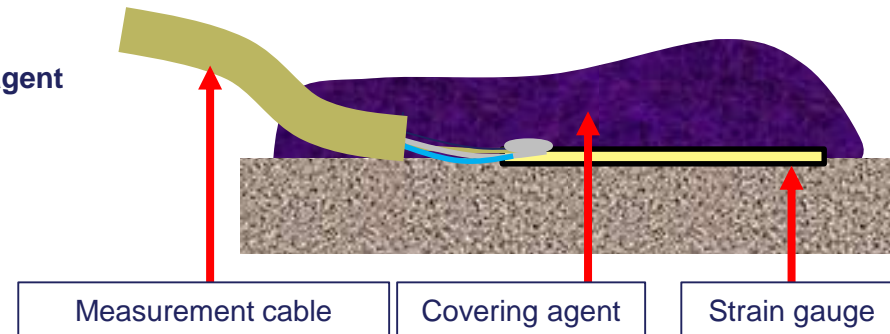
2. Using not qualified covering agents

- Be careful only using qualified covering agents. Wrong covering agents could influence the gauge (corrosion...)
- Chemical interaction with strain gauge grid



3. Creation of unintended mechanical resistance by covering agent

- Ensure not to change the mechanical behavior of the structure by using covering agents/constructions which resist the strain of the structure



Protection of strain gauges



1. PU140: Polyurethane lacquer

Perfect for lab testing and easy protection – quick curing

2. SG250: Silicone rubber

Solvent-free- good mechanical- and water protection

3. NG150: Nitrile rubber

Wide temperature range - resistant against oil and fuel - good electrical isolation

4. AK22: Viscous putty

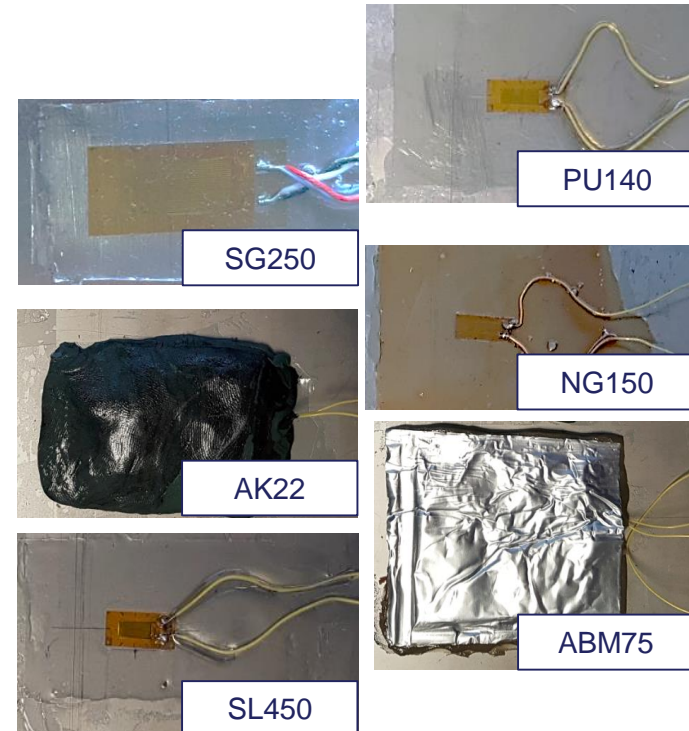
For high pressure conditions – water protection – no solvents

5. ABM75: Aluminium foil with kneading compound

Best barrier against water and humidity – for long time exposure – monitoring

6. SL450: Transparent silicone resin

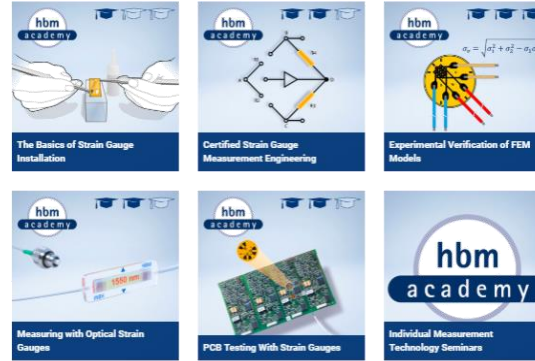
For high temperatures - resistant against humidity, oil, fuel and many solvents



Starting working with strain gauges....

Many sources of potential hazards during strain gauge installations...

1. Get in personal contact with our experts and visit our **HBM Academy** or book our experts for a seminar in your company



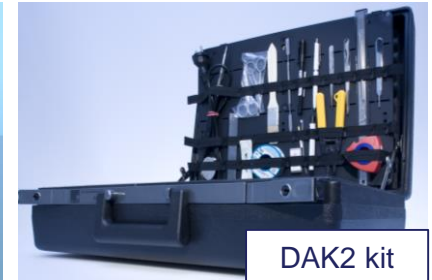
2. HBM offers complete **starter packages** including adhesives, strain gauges...

(DAK1 + DAK2)

3. Contact our **Service team** for your complex projects for help



DAK1 kit










DAK2 kit

4. Start thinking in **lifecycles** when designing, testing and validating your product



More information can be found on our website ... our knowledge data base

- <https://www.hbm.com/en/0014/strain-gauges/>
- <https://www.hbm.com/en/7074/strain-gauge-fundamentals/>

| | | | |
|---|---|--|---|
| <p>Y Series</p>  <p>The universal series for strain measurements. More than 2,000 different types of strain gauges available for nearly any measurement task.</p> | <p>M Series</p>  <p>M series strain gauges can withstand temperatures from -200 to +300 °C and up to 10 million load cycles, with a high resistance to alternating loads.</p> | <p>C Series</p>  <p>The strain gauges of HBM's C series are the low-cost specialists for temperatures up to -259°C, +250°C. They are also particularly flexible.</p> | <p>KFU Special Strai...</p>  <p>The strain gauges of the KFU series are proven specialists for applications where high temperatures up to 350°C may occur - even across several days.</p> |
| <p>Transducer Strain...</p>  <p>The excellent combination of output and cost advantage: strain gauges for manufacturers of measurement transducers.</p> | <p>Special Strain Ga...</p>  <p>Strain gauges for special applications, e.g. for residual stress analysis, temperature measurement, welding, crack propagation, etc.</p> | <p>Strain Gauge Acces...</p>  <p>With its strain gauge accessories, the HBM product range offers everything necessary for a good strain gauge application.</p> | |

1. Basics of Strain Measurements and Experimental Stress Analysis



How does an Electrical Strain Gauge Work

Watch this video to learn how an electrical strain gauge works.

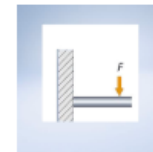
[Read more](#)



Strain Measurement Glossary

A useful guide of technical terms to help you understand the precise concepts related to the fun

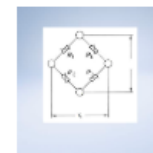
[Read more](#)



Experimental Stress Analysis

Experimental Stress Analysis (ESA) is the analysis of the mechanical stress state in materials, v experiments using strain gauge measurements. Learn the existing types of stress, their origin a stress from measured strains by reading about it below.

[Read more](#)



Wheatstone Bridge Circuit

The Wheatstone bridge can be used in various ways to measure electrical resistance: For the de of a resistance by comparison with a known resistance, for the determination of relative change and theory of operation.

[Read more](#)



Experimental Stress Analysis Reference Book

The strain gauge has become an essential tool in stress analysis, part optimization, safety testi



Find the equivalent strain gauge

Enter strain gauge part numbers from other manufacturers and immediately find the HBM equivalent.



Strain gauge catalog

Download the strain gauge catalog (PDF)

HBM's reference book

Download our reference book: *An Introduction to Measurements using Strain Gauges*.



Any questions?

- If you have any questions, feel free to email the presenter directly:
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