Challenges with electrical vehicles

Electrical vehicles are available in many different versions. What´s the problem?

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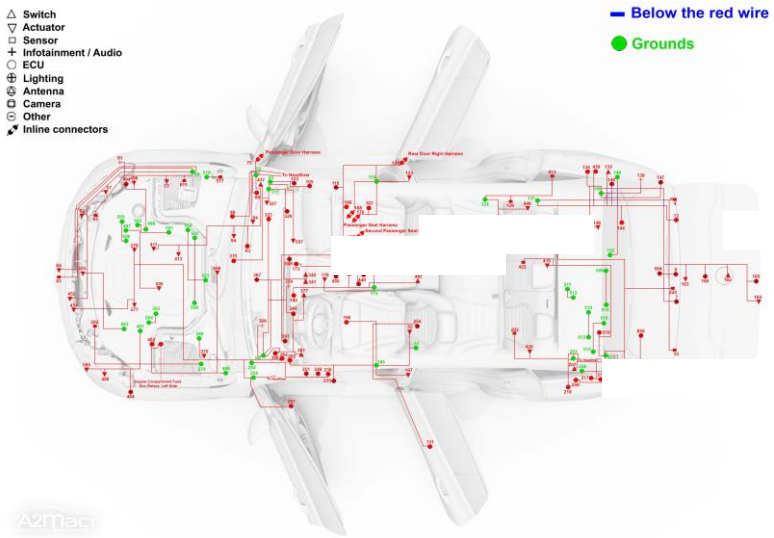
Electrical vehicles

- **Increased number of electrical contacts in EV**
  - EI-motor, Electrical systems (ADS), Battery, etc.
- **Expected higher life length**
  - > 1000 000 km , EMC properties
- **Higher currents in HV components**
  - Up to 1000A
- **Increased problems due to <u>combined loads</u>**
  - Temp, Vibrations, Currents, Environment →Increasing!
- **Light weight constructions:**
  - Multimaterial constructions
  - Aluminium conductors substitute copper

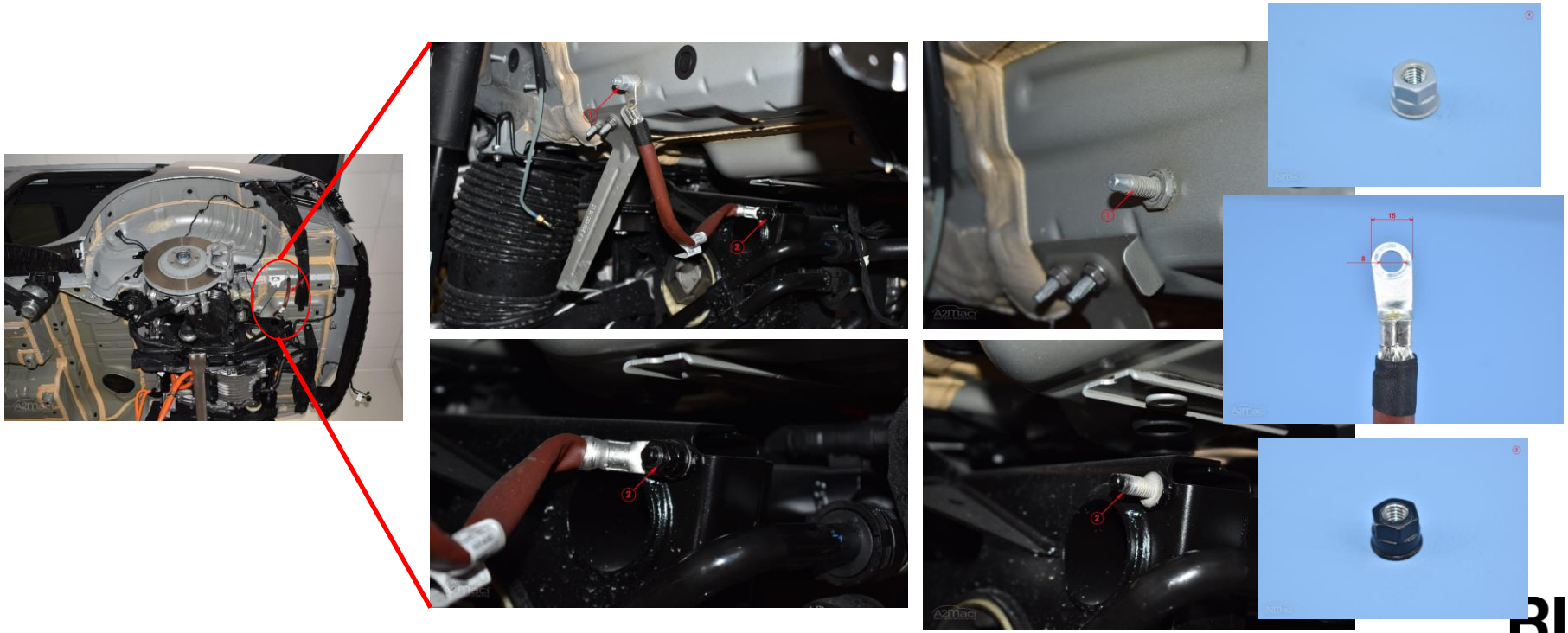


What are the challenges?

- Raw materials for batteries have limited supply and are expensive
- Electricity has limited supply and may be more expensive
- Batteries are very heavy and expensive
- Voltages are very high
- Currents are very high and varying during driving
- **Contacts/joints are exposed to high loads and may lose conductivity**
- EMC, ESD
- Safety/crash/maintenance
- Recycling/reuse/disassembly

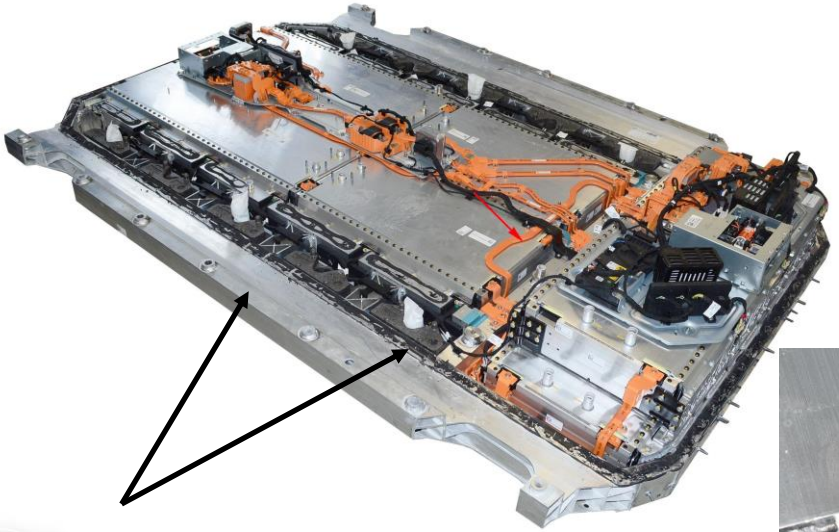
Knowledge levels about contacts

Examples of electrical contacts: Grounding

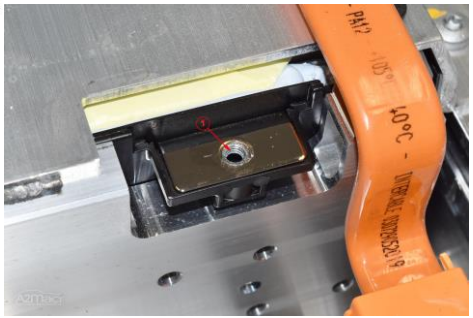


Source: A2mac1 – Mercedes EQC

Examples of electrical contacts: HV Bus bar

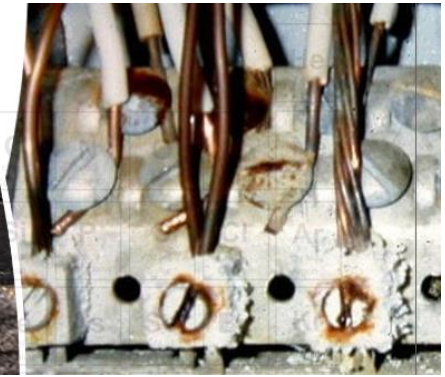


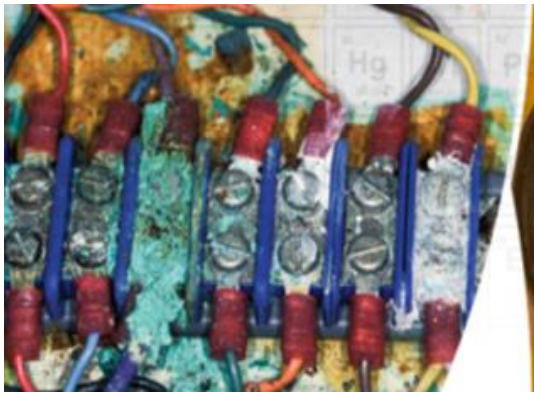
HV Bus bars



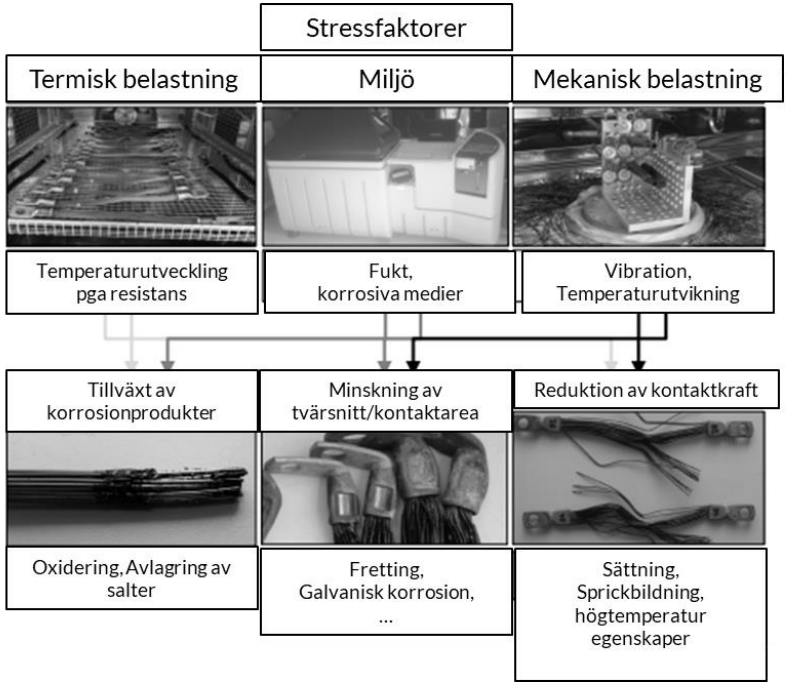
Source: A2mac1 – Mercedes EQC

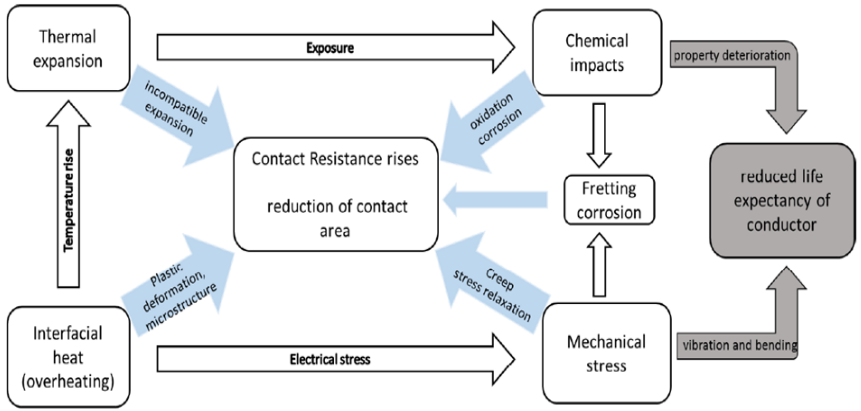
Corrosion / oxidation of contacts



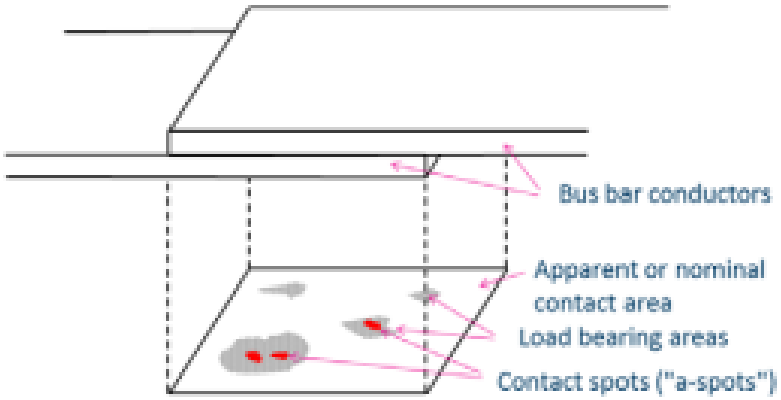


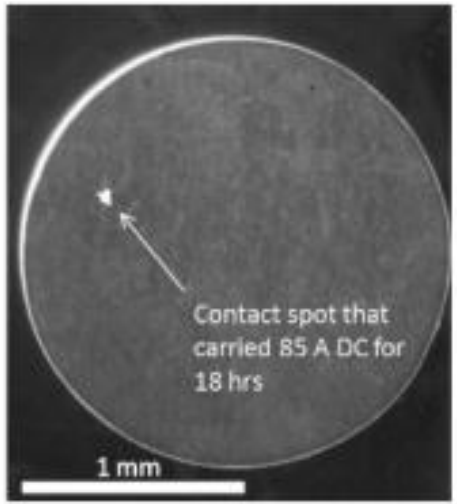
Combined loads





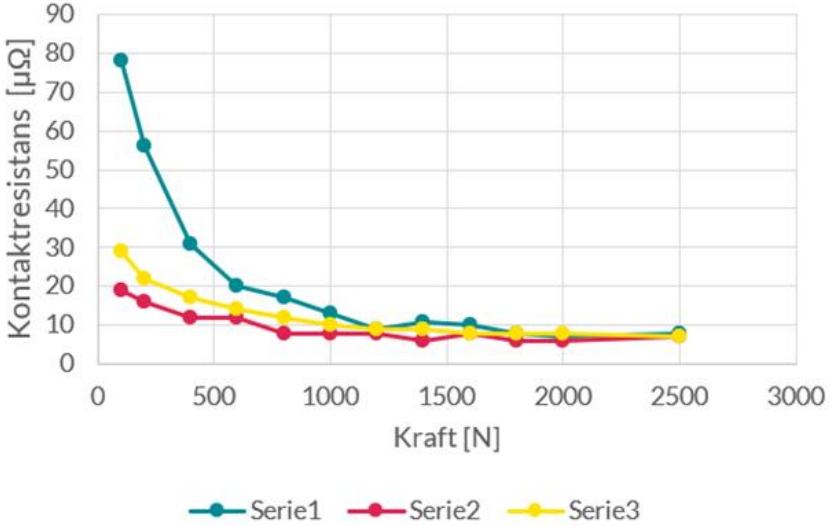
A-spots – Contact surface





Measurement in tensile rigg

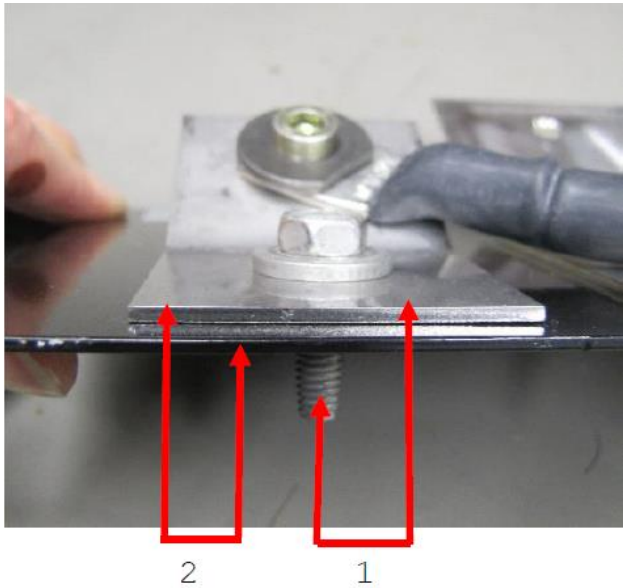
tinplated copper contact pressed by M10 screw against nickelplated copper bar

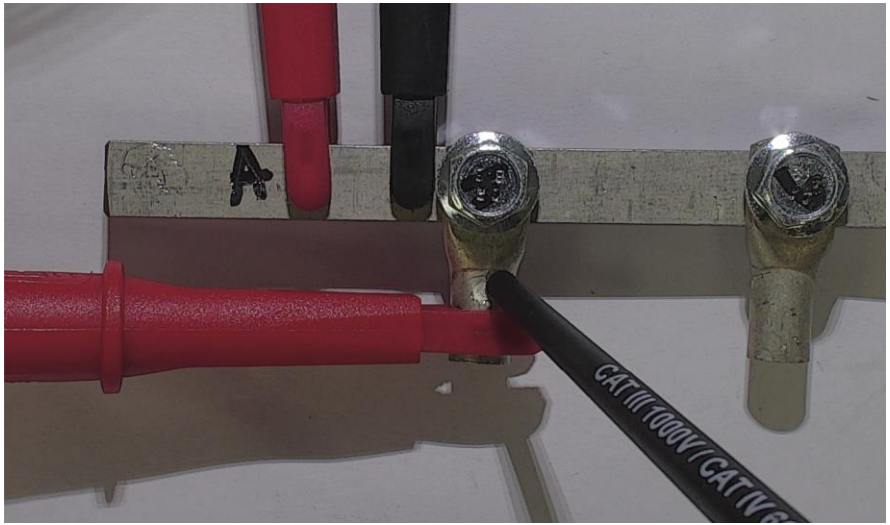


M10 8.8 can give clamping force over 30 kN

MicroOhm measurement

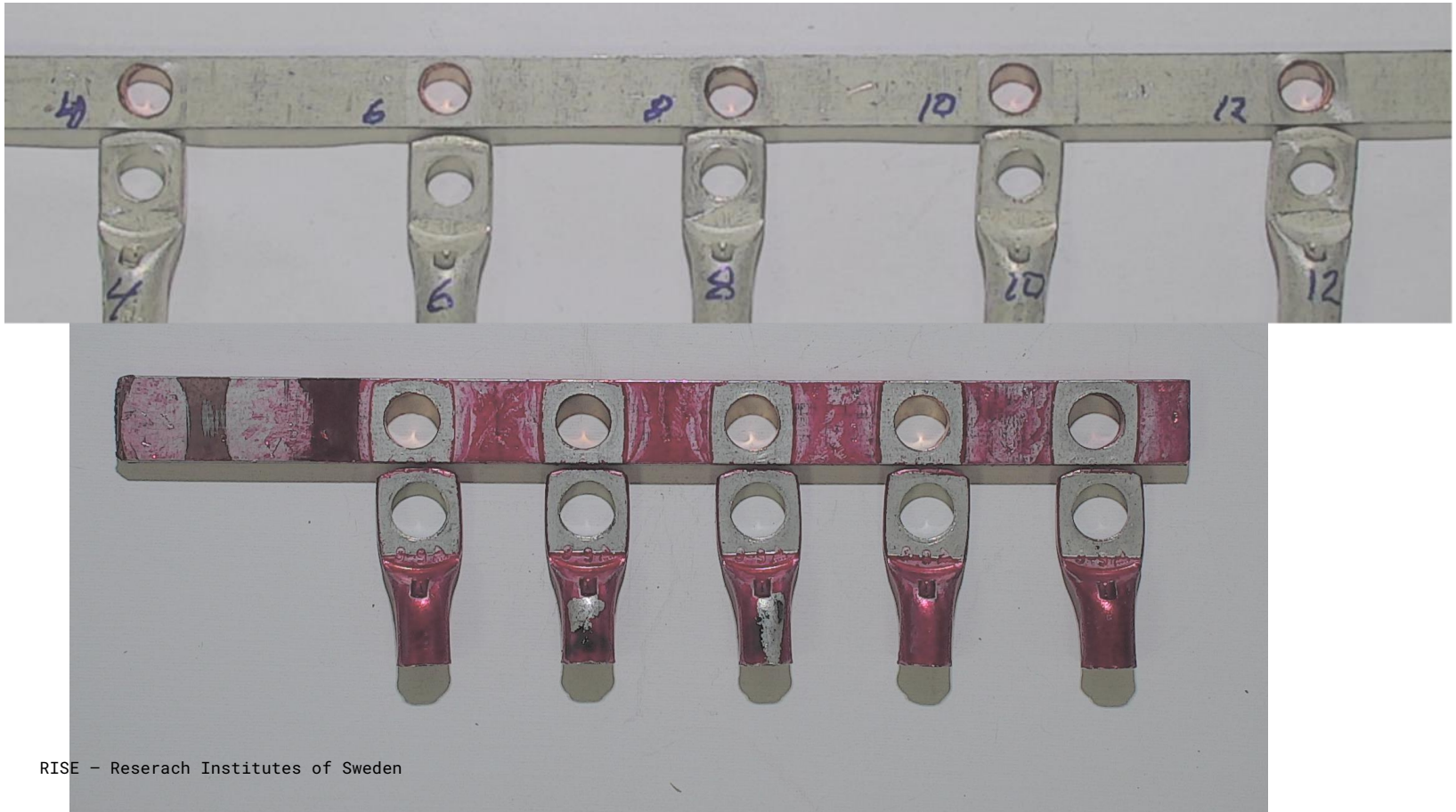
Red = Current Black = Voltage



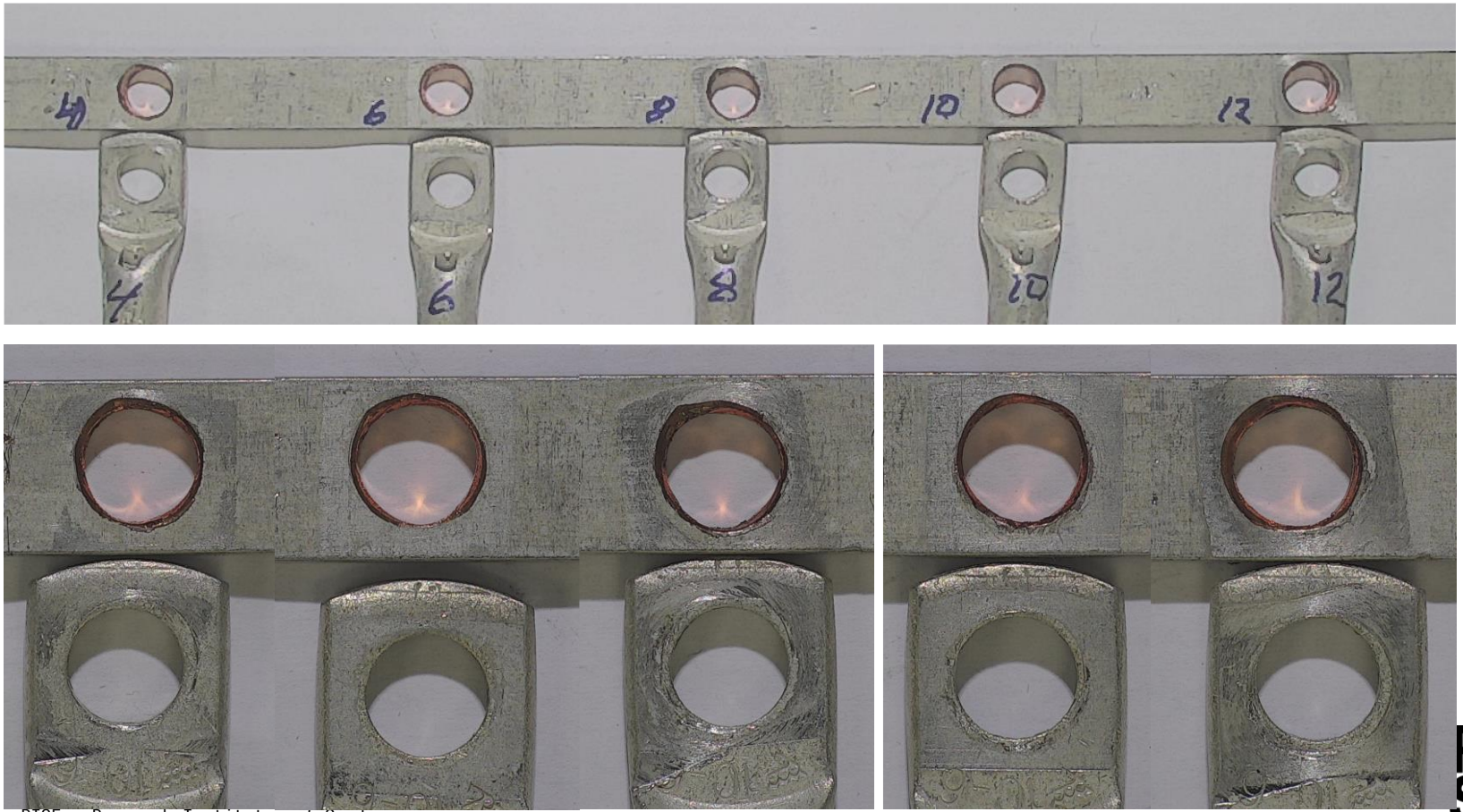


1 mΩ => 100 W in heat/lost energy

Climate test and penetrant, Sn-Cu – M6

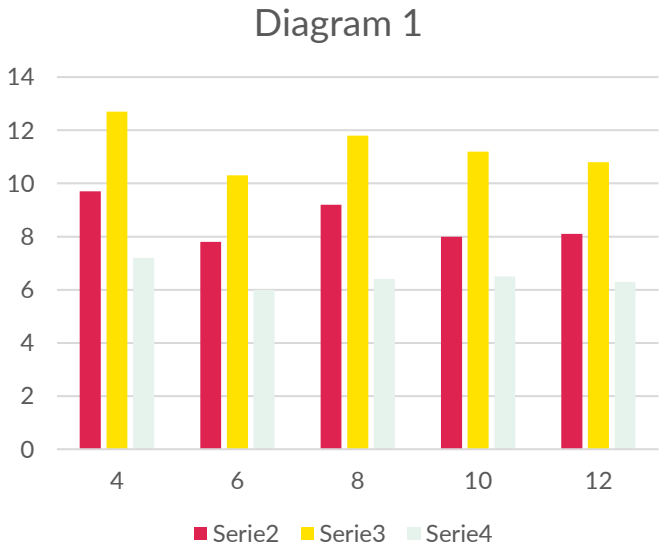


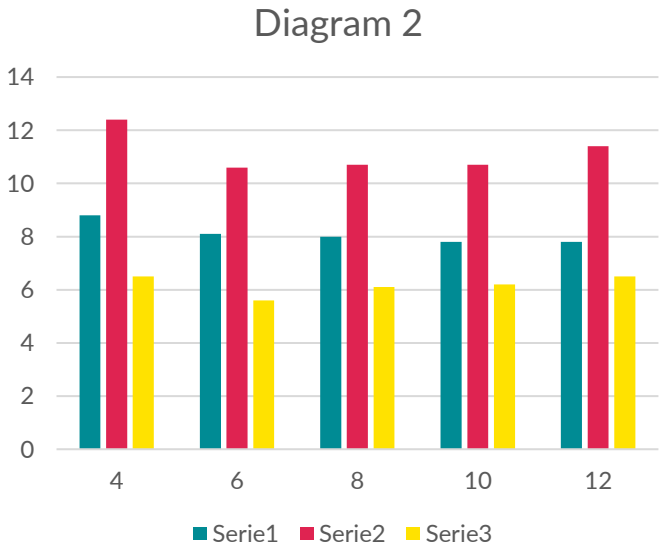
BarA – after Climate test



Resistance

Virgin – after 10days Climate test, bar - contact / screw





A good screw joint

- Assembled materials should be hard/rigid and not deform plastically
  The screw joint can then be mounted with large stretch of the screw
  The contact pressure can then be maintained and external loads are mainly taken up by the material, and not the screw

- The strength of the screw should be fully utilized, i.e. assembled with a large stretch near or above plastic deformation
  The risk of the joint losing clamping force, which gives impaired conductivity and increased risk of fatigue, becomes minimal

- The clamp length should be long
  The material can be deformed and large typesetting can occur without total loss of contact pressure

- **Nothing of the above is fulfilled for most electrical contacts!**

Challenges - assembly of contacts

- Torque
- Soft materials and short clamping lengths
- Conducting or insulating oxides
- Conductivity, clamping force, contact surface
- Setting, loss of clamping force, oxidising, increased resistance
- Sealing, battery boxes and electronics
- Corrosion protection – conductivity – EMC
- Personnel, education, equipment, documentation
- Testing / Quality ?

Concept
Material
Coating

Exposure
Load

Evaluation

Copper, aluminium
brass, steel

Hardness Friction
Galvanic potential
Conductivity

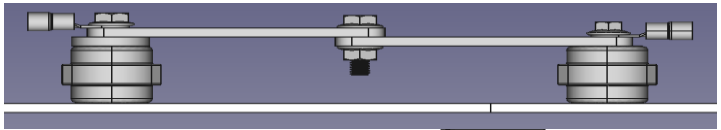
Sn, Ni, Ag, Au
Zn, ZnNi, ZnFe,,

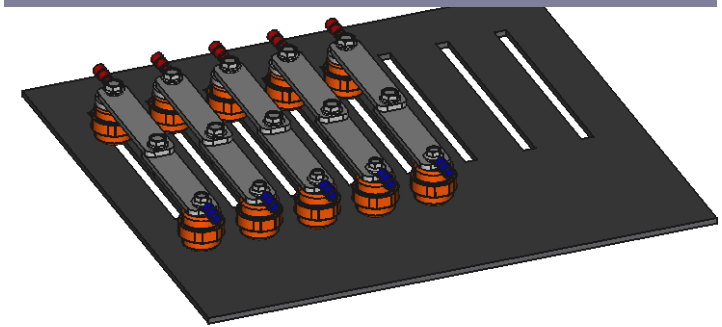
Climate Temp Moisture
Current Heat
Corrosion
Vibrations

Combined load

Visual
Resistance
Heat
Clamping
Surface
Corrosion
Contact

Test objects





Short screw

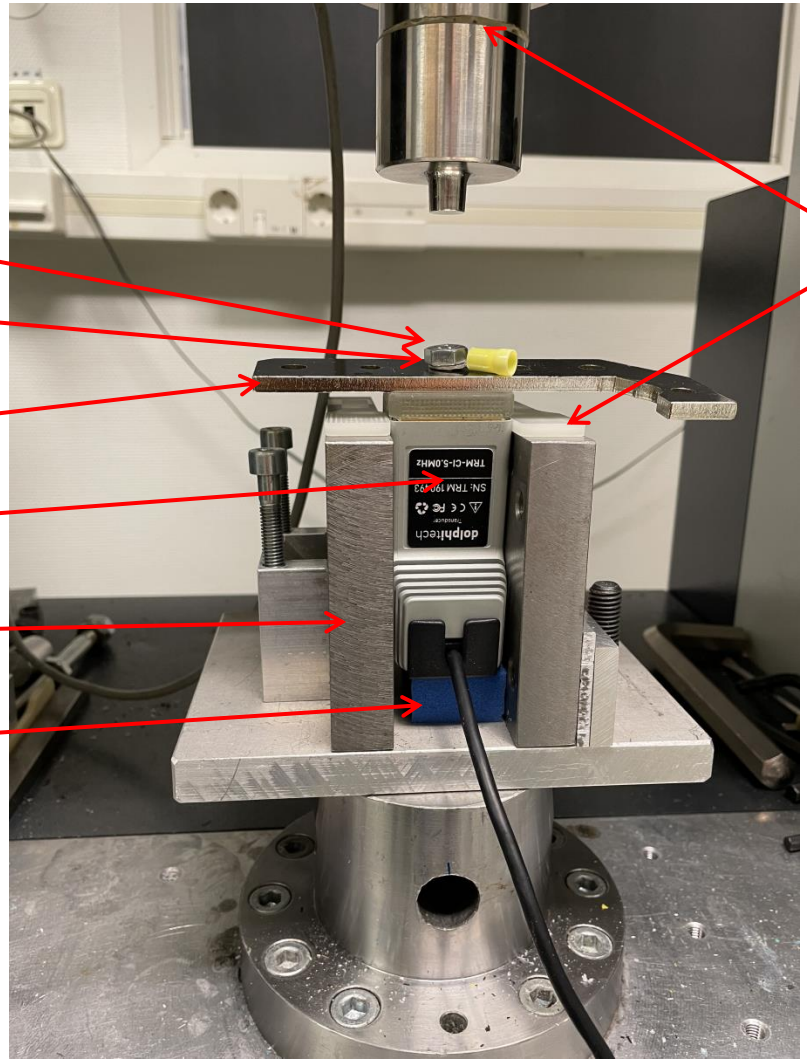
Crimp contact

Bus bar

Dolphicam

Support

Elastic foam



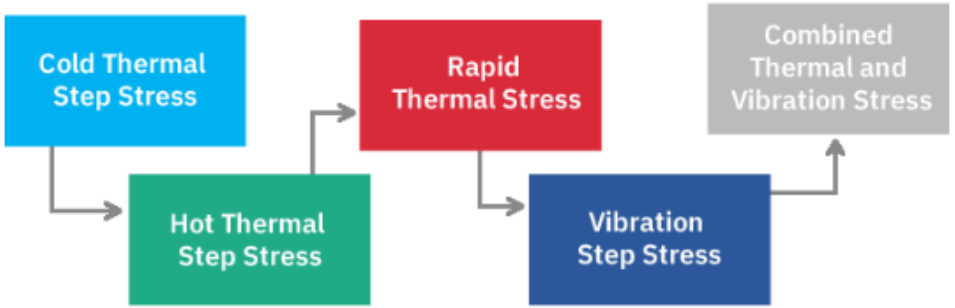
Insulation

4-point resistance measurement in-between bus bar and crimp contact

RI.SE

HALT / HASS Testing

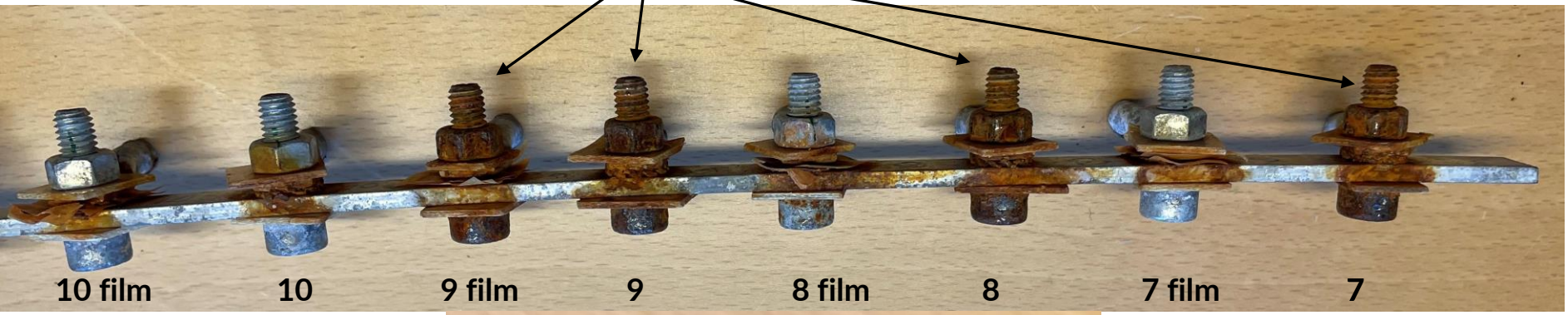
Highly Accelerated Life Test / Highly Accelerated Service Screening
Temperature cycling and increasing vibrational load,
separately or in combination



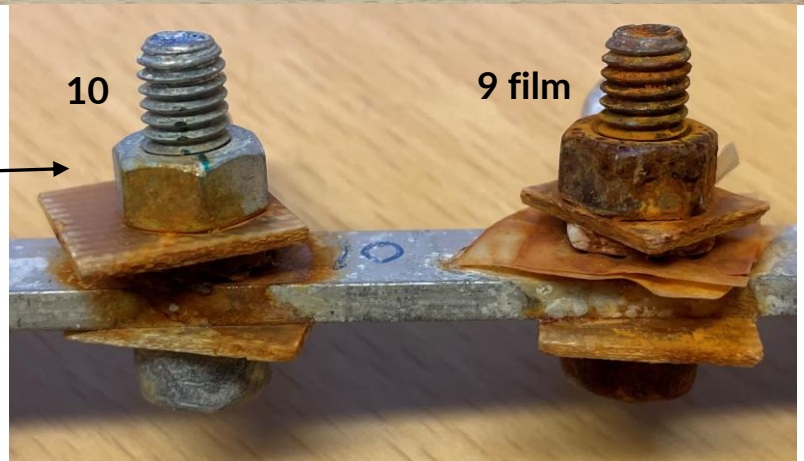
Max loads are:
•Cold: -100 ° C
•Hot: +200 ° C
•Temperature change rate: 60 ° C / min for the test object
•Vibration: 50 g RMS.
Temperature cycling and vibration are also performed in combination.
HALT testing requires functional testing during the test to detect when errors occur. It also requires fixture development to be able to fix the product at the vibration table

Photo of specimens after finished test, exposure 6

Galvanic coupling between busbar and screw



Screw and nut isolated from busbar



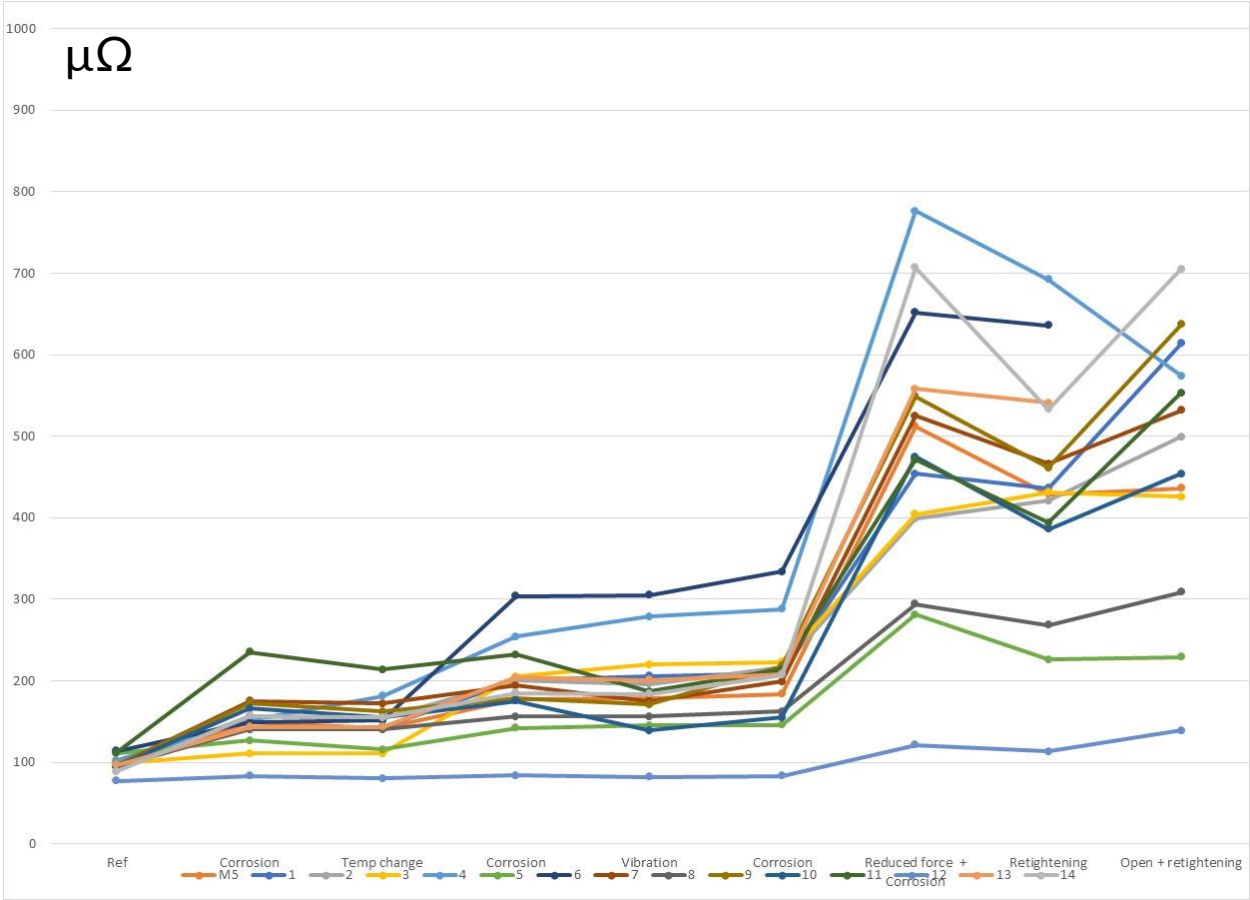
Resistance with EVOH film

Samples with the EVOH film had higher resistance from the beginning. With time the rate of degradation was about the same.

The film did not improve the degradation resistance as hoped with the hypotheses.

These serrated washers did cut through the film, but some plastic could remain in the contact surfaces.

One possible explanation could be that the film gets oxygen permeable when it becomes wet.



Elyfog

Components, material

- Screw: material, dimension, coating,,
- Screw: design, flanges, features,,
- Nut: sealing, locking,,
- Washer: dimension, spring,,
- Bus bar: material, dimension, coating,,
- Pol shoe: material, dimension, pol,,

Surface properties

- Coating: conductivity, corrosion protection, friction, oxides, galvanic potential, top-coat,,
- Oxides: volume, passivation, conductivity, moisture absorbance,,
- Deformation, hardness, ductility,,

Elyfog

Assembly

- Torque
- Clamping force
- Hålplantryck
- Thread engagement
- Helicoils
- Locking
- Setting
- Twisting (Medvridning?)
- Cable clamming

Environment and load

- Combined testing:
  vibration, temperature cykling,
  moisture/corrosion, current
- Standardised test methods
- Define a good elektrical contact

Instruktions and education

- Design guidelines – best practices
- Safety regulation
- Handbook chapters
- Education
- Standard for quality assurance

Summary of electrical contacts

- The resistance of metals in contact is generally very low even at low contact pressure but can vary significantly between different concepts
- High and potentially harmful resistance is unlikely to occur until the contacts have been exposed to harsh environmental and mechanical stresses in the form of moisture, salts, vibrations, and varying current and temperature
- Growth of insulating oxide layers and loss of clamping force must be minimised by proper design, material selection and assembly of the connections
- Contacts must be designed not only for the electrical properties but also for the mechanical
- Testing and quality assurance for electrical contacts needs to be developed