

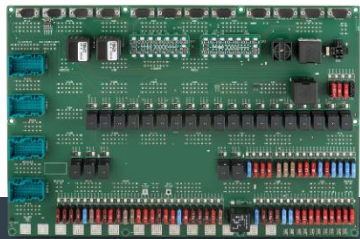
Würth Elektronik ICS – Ronald de Jeu

HIGH VOLTAGE POWER DISTRIBUTION UNIT AND FUSE SELECTION IMPORTANCE

WELCOME TO HV FUSES!



**WÜRTH
ELEKTRONIK**
MORE THAN
YOU EXPECT



Power Electronics & Energy Storage event
28 mei 2024 | 1931 Congrescentrum 's-Hertogenbosch

ENERGY STORAGE



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BUSINESS DIVISIONS

Electronic & Electro-mechanical Components



Year of foundation
WE Group:
1971

Employees
WE Group:
7,870

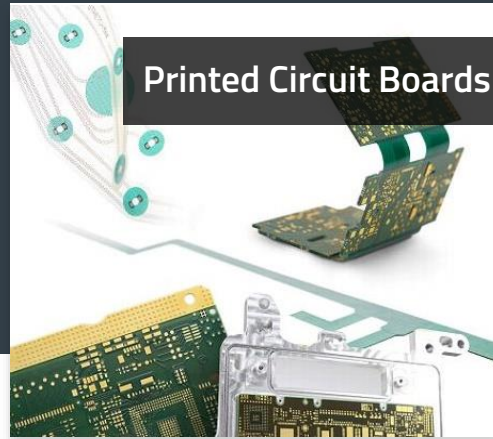
Turnover 2023
WE Group:
EUR 1,24 billion*

Year of foundation
WE ICS:
1984

Employees
WE ICS:
640

Turnover 2023
WE ICS:
EUR 137 million*

Printed Circuit Boards



Intelligent Power & Control Systems



*preliminary financial statements

**POWER
ELECTRONICS**

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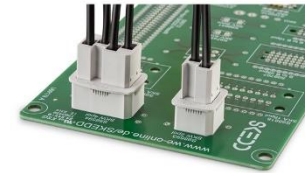
WE INTELLIGENT POWER AND CONTROL SYSTEMS

SYSTEMS FOR
MOBILE MACHINES AND
COMMERCIAL VEHICLES



POWER DISTRIBUTION

POWERFUL COMPONENTS
FOR A WIDE RANGE OF
APPLICATIONS



HIGH VOLTAGE SOLUTIONS



HMI SOLUTIONS



ELECTRONIC CONTROLLERS



PCB COMPONENTS



**POWER
ELECTRONICS**

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AGENDA

1. PDU presentation
2. PDU components
3. Fuse sizing
4. Thermo Simulation



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1. PDU PRESENTATION



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1. PDU presentation

POWER DISTRIBUTION UNIT

1

Distribute the energy safely within the vehicle by switching loads when needed

2

Protect the vehicle's electrical network and provide measurements to vehicle controllers

3

Enable safe and easy maintenance



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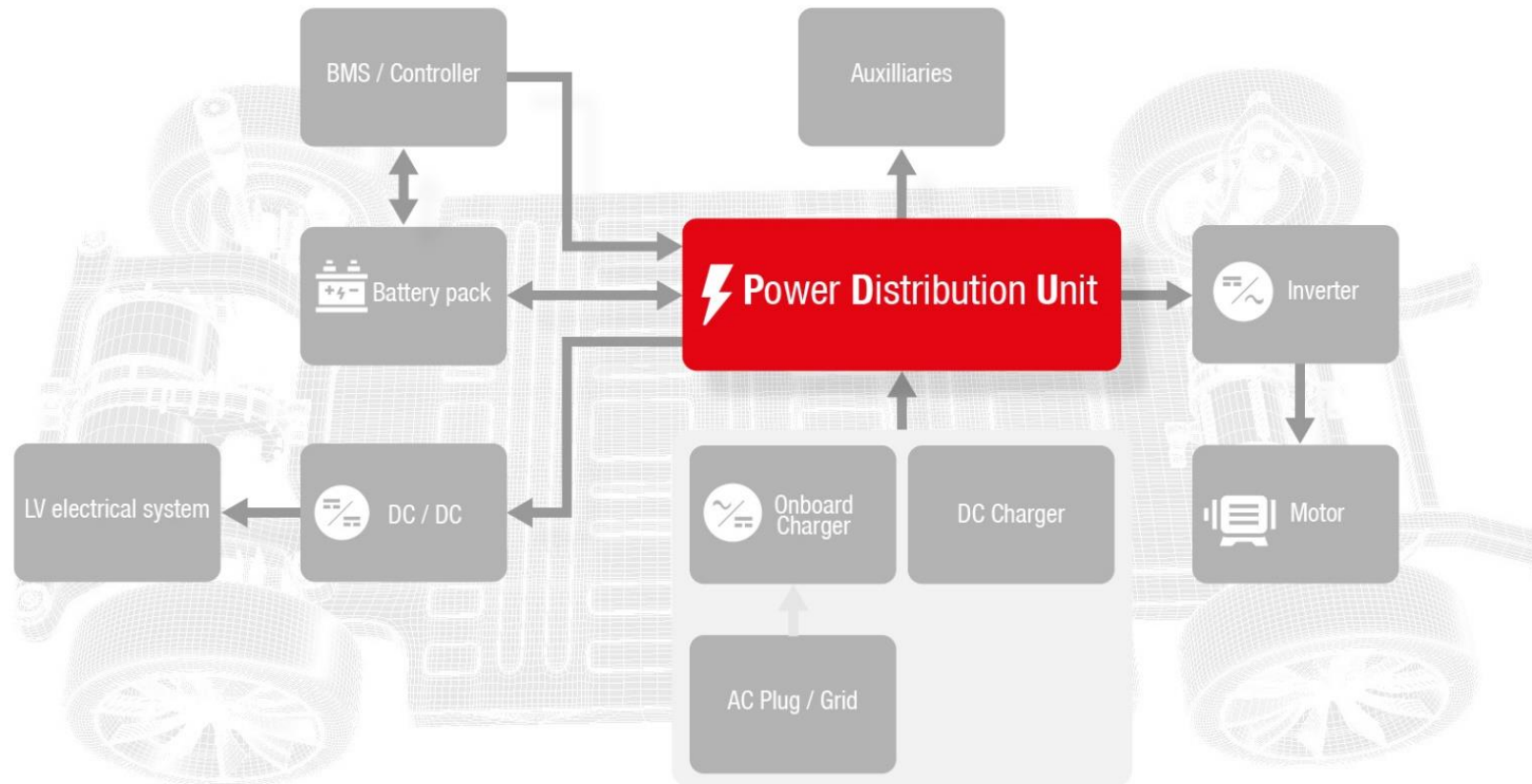
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1. PDU presentation

BATTERY ELECTRIC VEHICLE ARCHITECTURE



1. PDU presentation

POWER DISTRIBUTION UNIT EXAMPLES

Measurement

- Current measurement on CAN
- Temperature measurement

400 A main fuse

- 400 A 600 VDC fuse integrated

Precharge circuit

- Using Gigavac minitactor & PTC

HVIL loop

- Snap action switch for lid opening detection
- HV-Interlock connectors

Fuses

- 2 x 8 A to 30 A
- 20,000 A interrupting rate

GIGAVAC contactor integrated

- Directly plugged into PCB



100 % connectorised system

- TE HV800
- TE HVA 630
- Deutsch connector for LV

- 600 VDC max
- 200 A nominal

2. PDU COMPONENTS



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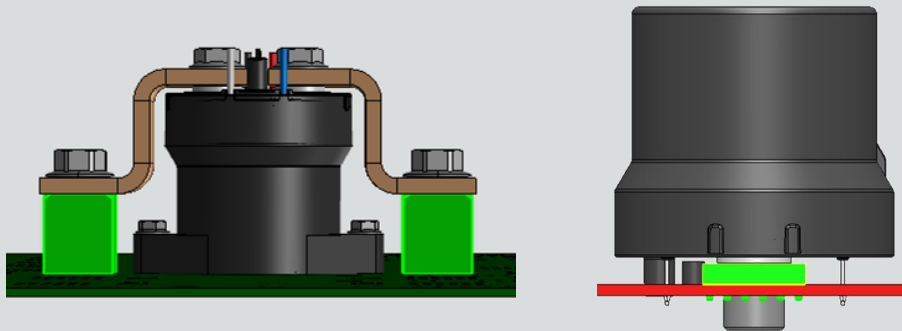
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2. PDU components

CONTACTORS

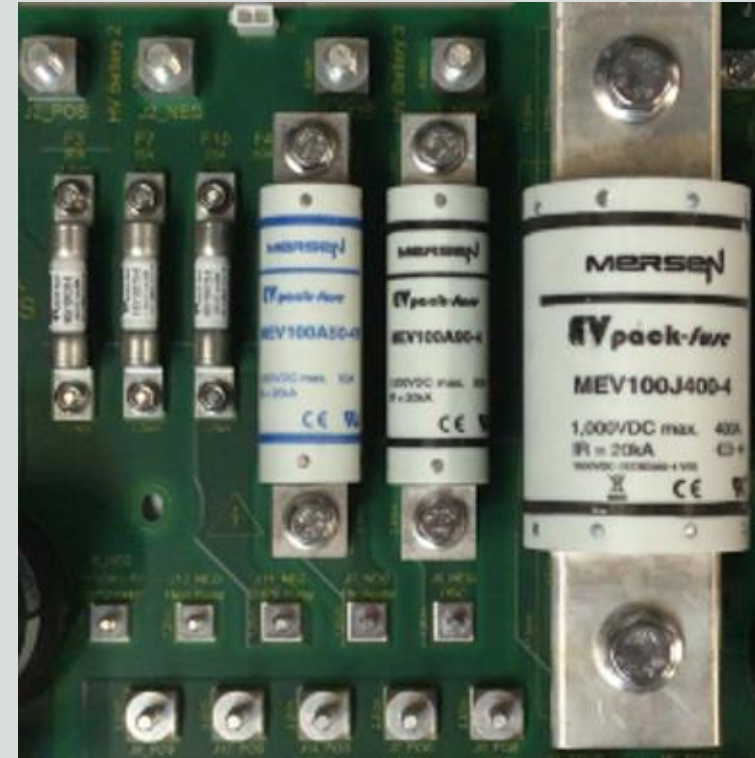
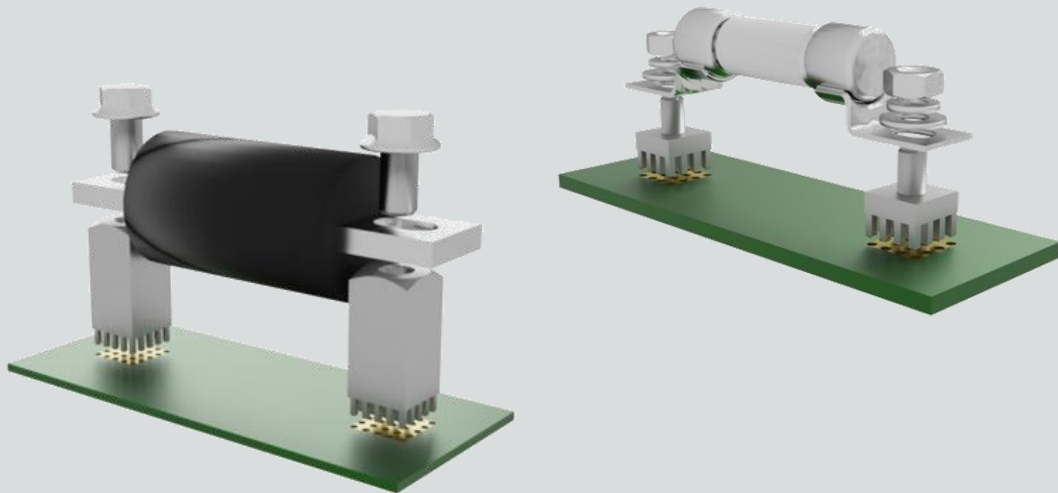
- Integration of different types of contactors (from different brands) with direct contact to PCB over Powerelements
- Connection of coils and auxiliary contacts with direct contact to PCB or with small wire harness (depending on contactor type)



2. PDU components

FUSES

- Possibility to integrate different types and sizes of fuses with direct connection to the PCB
- It could be from small to really big ones, with clean integration for service & maintenance



3. FUSE SIZING



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3. Fuse sizing

MISRATING OF A FUSE



3. Fuse sizing

MISRATING OF A FUSE

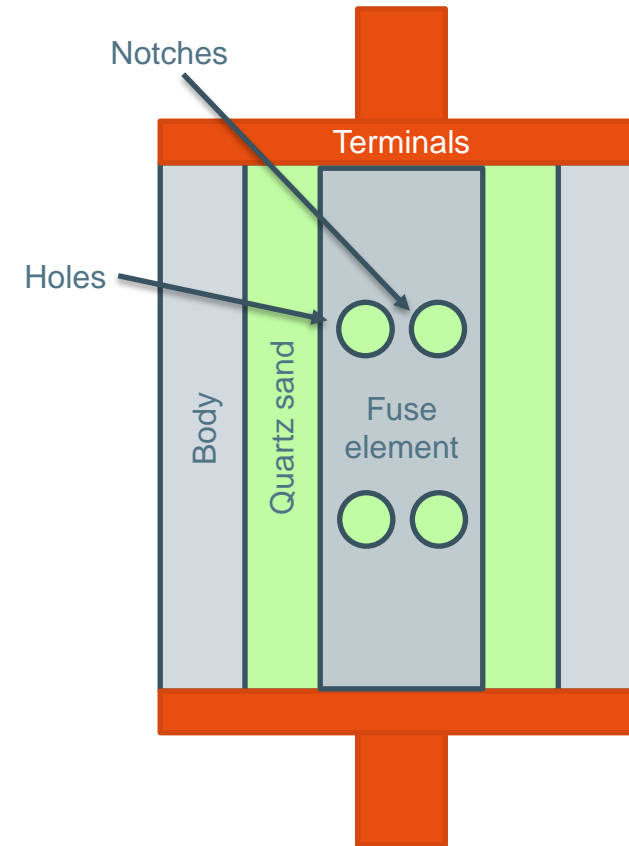
- A fuse is the ultimate safety device
- In case of misusing or misrating,
 - Damage on the system
 - Life risk for user



3. Fuse sizing

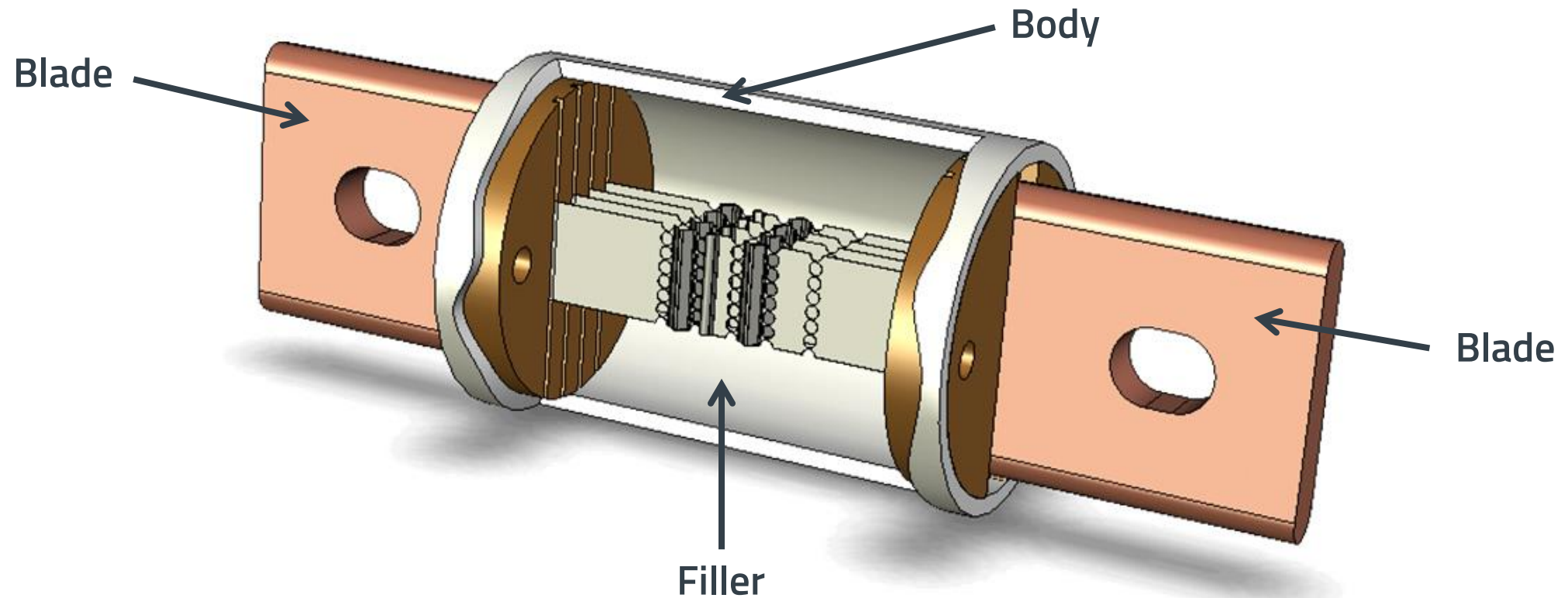
GENERAL PRINCIPLES

- **Three main functions:**
 - Current conduction (during normal operation)
 - Protection (during a current short-circuit or overload)
 - Insulation (after opening, one-time)
- **Four main parts:**
 - Body (for mechanical integrity – ceramic or composite)
 - Sand (for arc energy absorption (quenching) and heat transfer)
 - Terminals (for current conduction, cooling and mounting purposes – silver, aluminium or brass)
 - Element (for current conduction, notches melt when the current intensity is too high for too long – copper or silver)



3. Fuse sizing

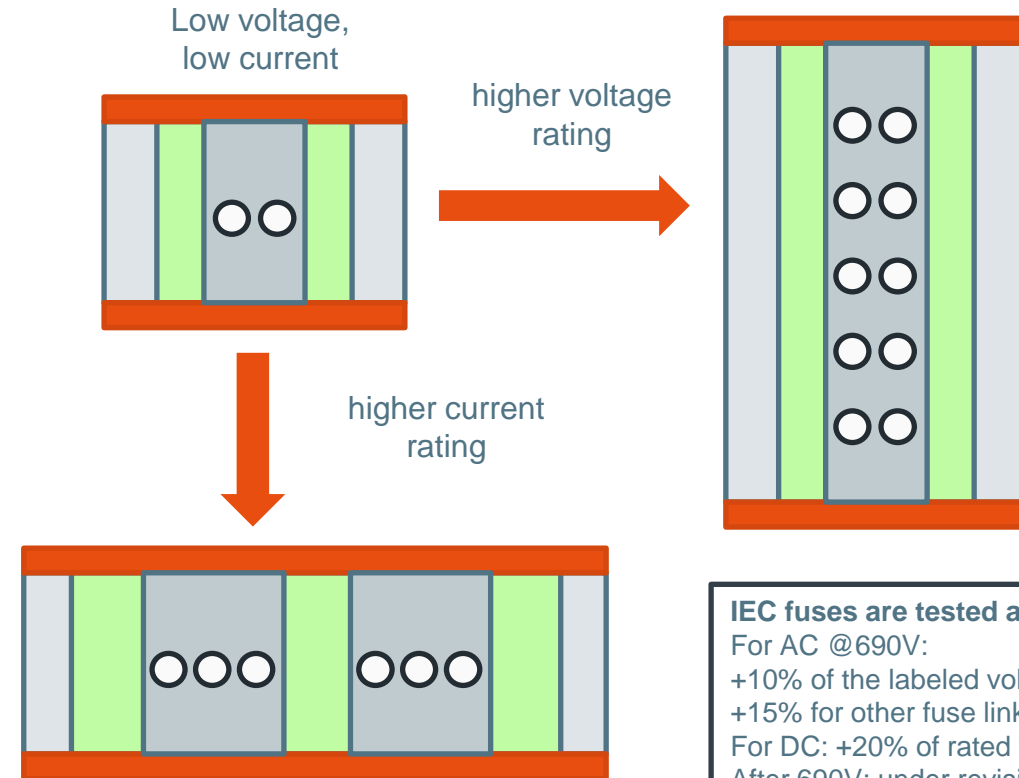
GENERAL PRINCIPLES



3. Fuse sizing

FUSE RATING

- Fuses also have a **voltage rating**, corresponding to the maximum voltage that they are designed to operate at in the worst specified conditions (maximum current, maximum time constant)
- Higher voltage rated fuses are longer and have more notches in series (= more voltage generated during arcing)
- Higher current rated fuses are wider and have more/thicker elements in parallel (= less current density)



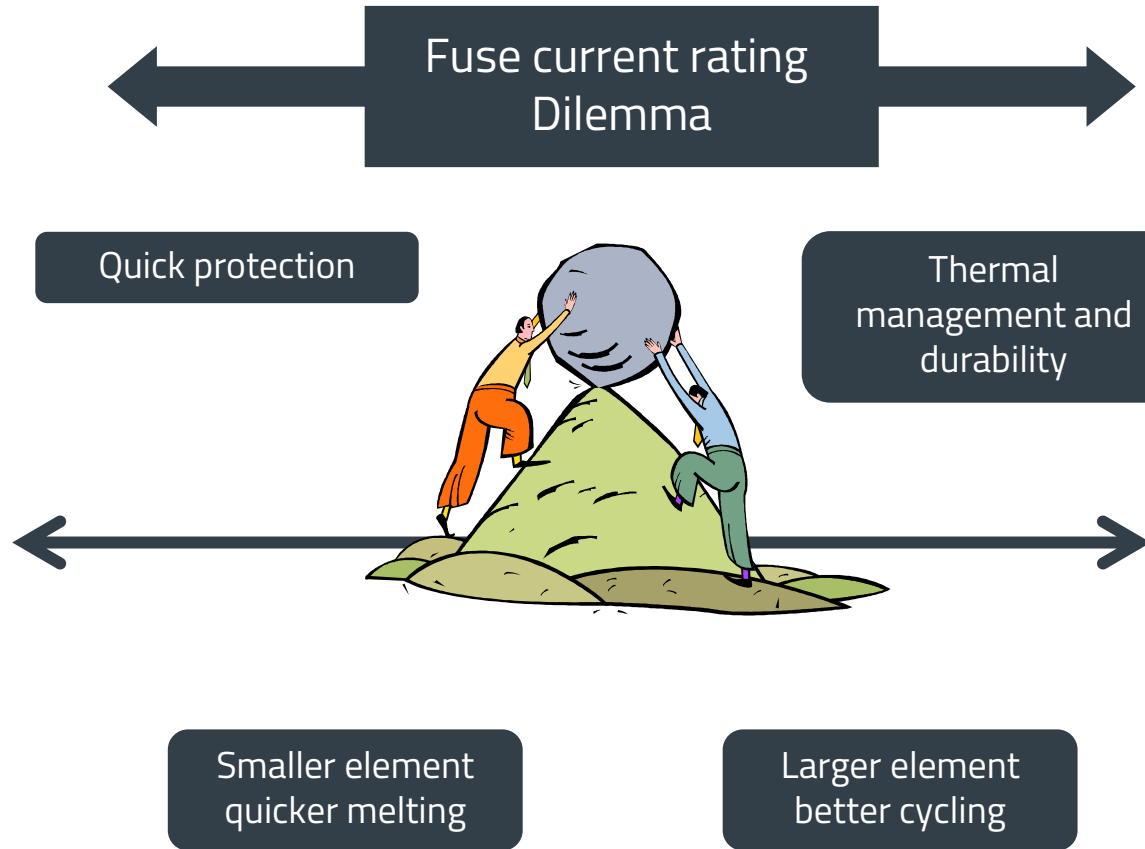
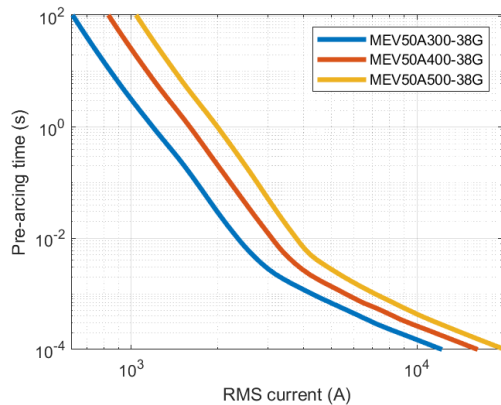
IEC fuses are tested at:
For AC @690V:
+10% of the labeled voltage
+15% for other fuse links
For DC: +20% of rated voltage
After 690V: under revision

UL fuses are tested at rated voltage

3. Fuse sizing

FUSE SELECTION

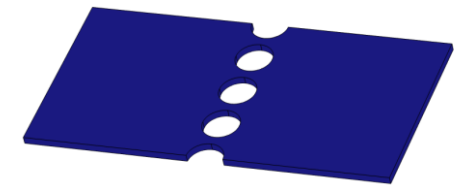
Electrical fusible link:
small wire/conductor that melts under short-circuit or overload



Current cycling causes:

- Temperature cycling
- Mechanical cycling

Ultimately leading to fatigue and failure



Fuse element temperature under current cycling



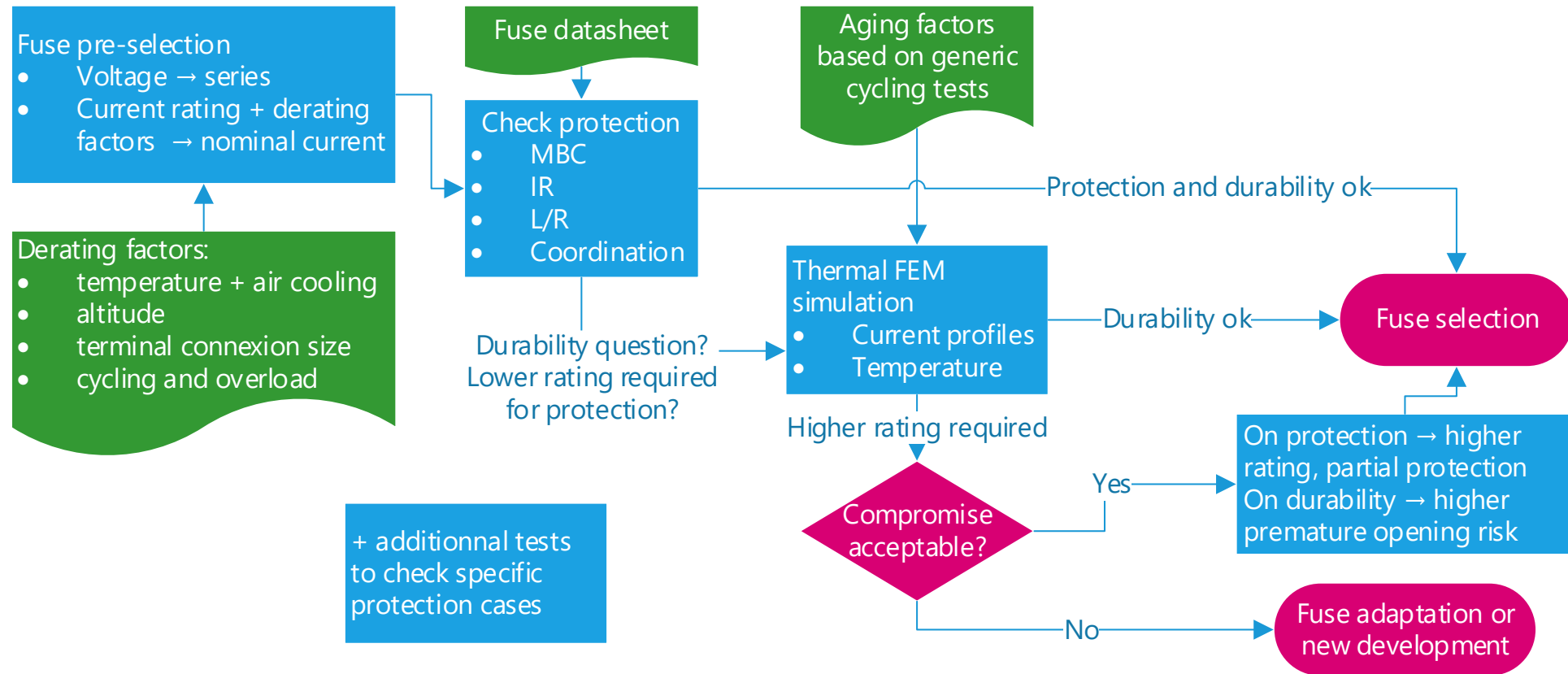
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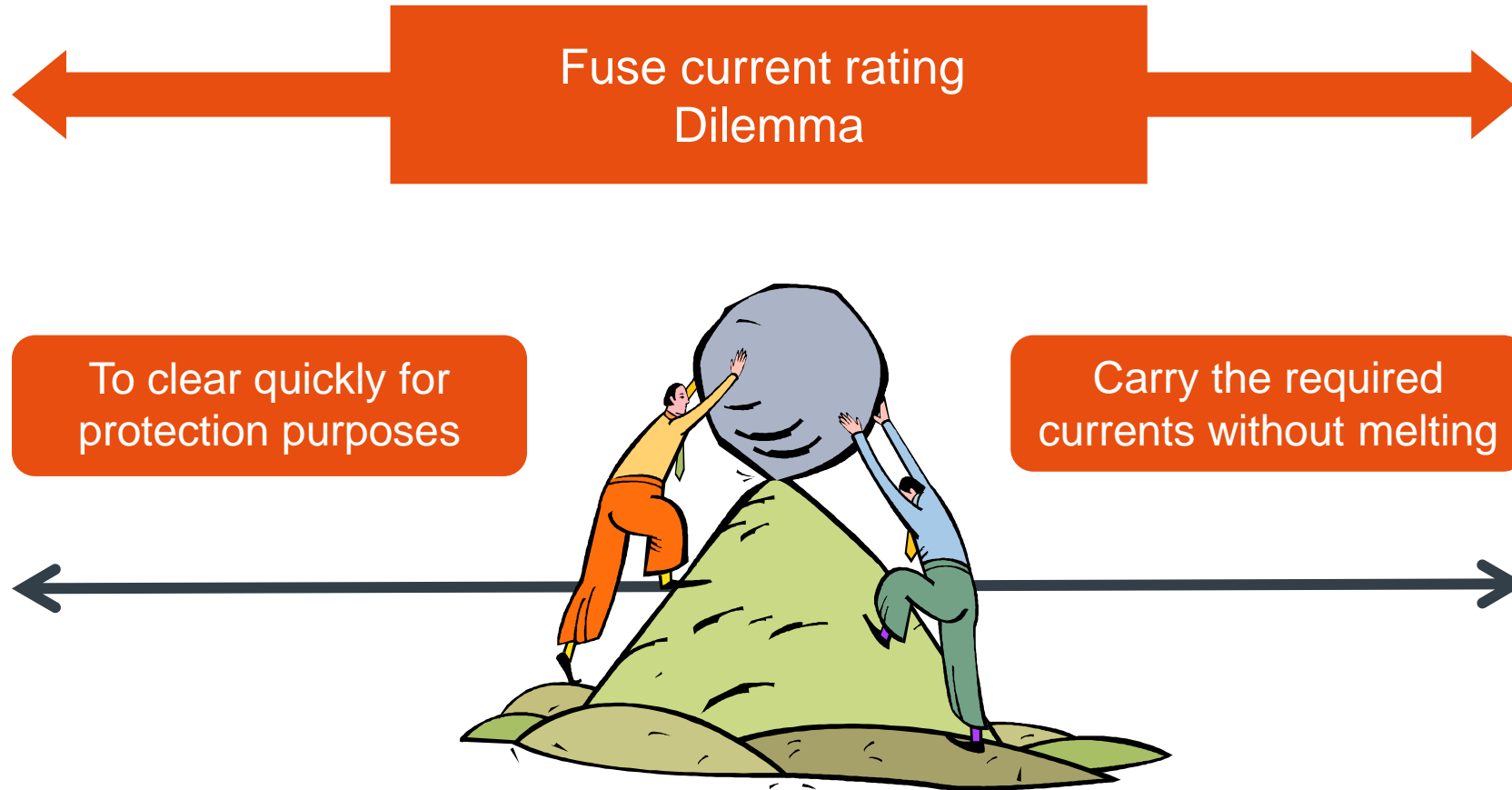
3. Fuse sizing

HOW TO SELECT THE RIGHT REFERENCE



3. Fuse sizing

HOW TO CHOOSE THE RIGHT REFERENCE



3. Fuse sizing

HOW TO CHOOSE THE RIGHT REFERENCE

- Short-circuit requirements
- Coordination with other devices
- Voltage
- Mechanical interface
- Application
 - Main fuse
 - Aux fuse
 - Charging fuse



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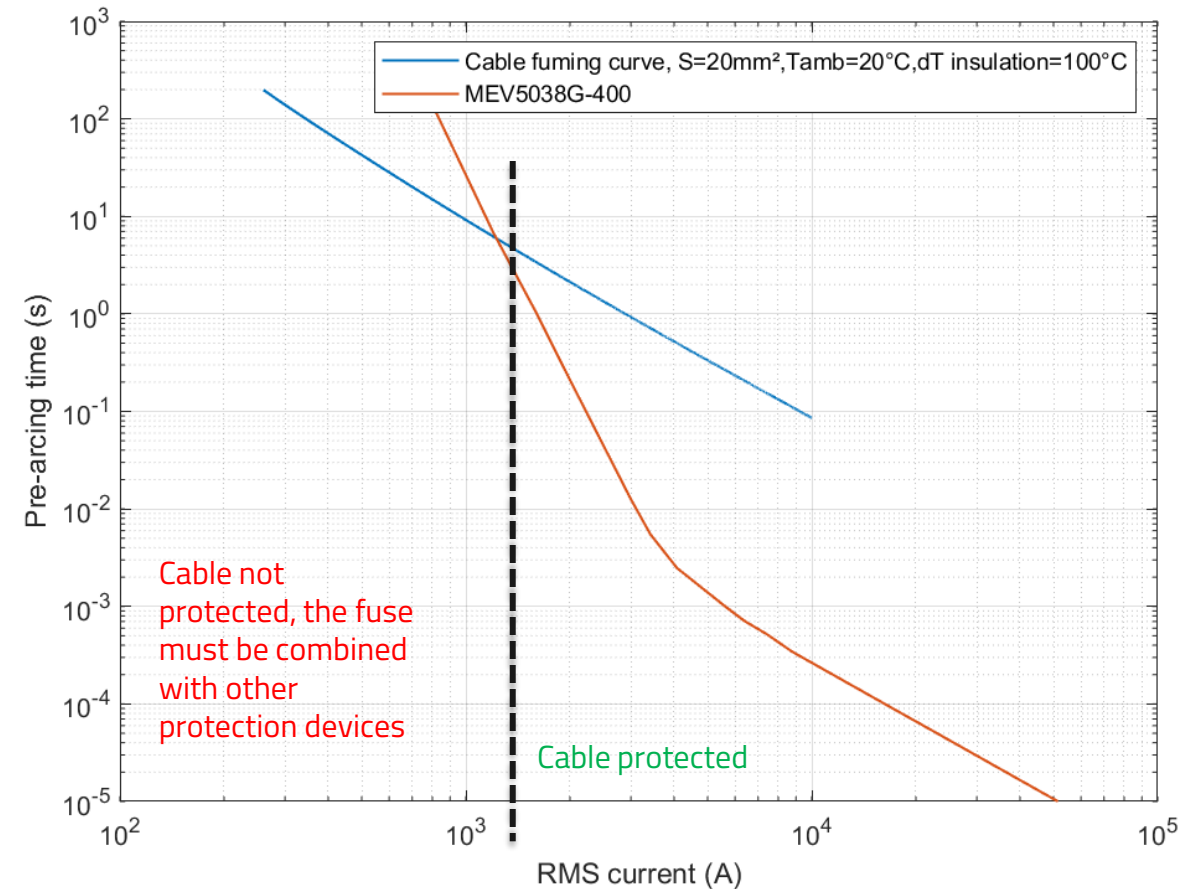
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3. Fuse sizing

HOW TO VALIDATE THE FUSE PROTECTION?

- The TCC is the main tool used to select a fuse for its protection function:
 - Represents time to reach arcing (not time to reach opening) for a given current
 - Log/log scale
- The fuse must melt before the protected equipment curve is reached (= the fuse TCC must be under the protected equipment TCC).



4. THERMO SIMULATION



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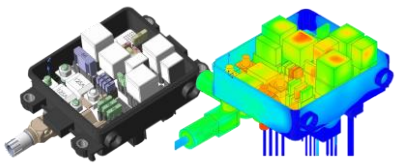
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3. Thermo simulation

ARGUMENTS FOR THERMAL SIMULATION

Why Simulation

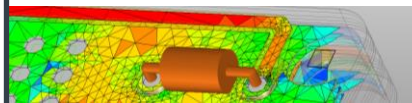


- **Cost savings**
- **Speed of development**
- **Reduced time to market**
- **Quality improvement**

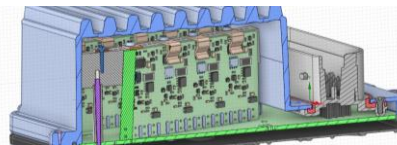
Optimize Design

EXAMPLES

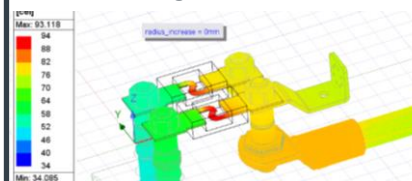
Layout: copper thickness / layer count



Boxes: shape



Thermal management: heat flux sink



REDUCE DESIGN LOOPS

Time gain:

- Layout : 20WD / loop
- Box tooling : 100WD / loop

Financial gain:

- Layout: 2k€ / loop
- Box tooling: 180k€ / loop

IMPROVE PRODUCT

Smaller product:

- Better heat flow

Higher currents:

- Better heat distribution

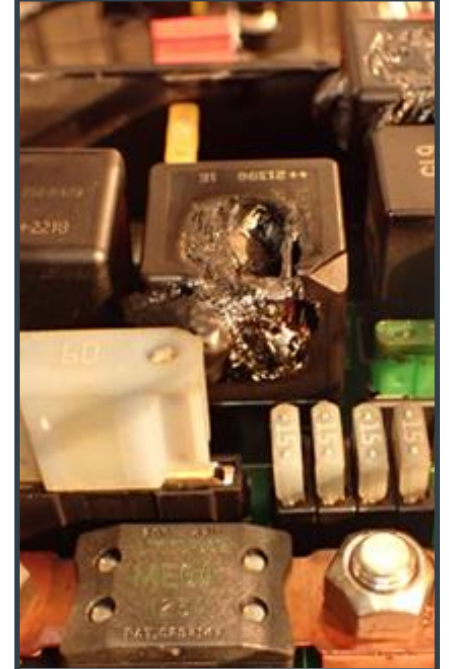
Better reliability:

- Lower temperature

Lower costs:

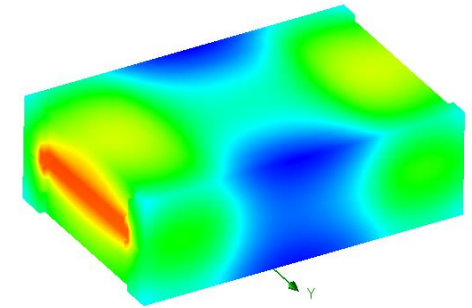
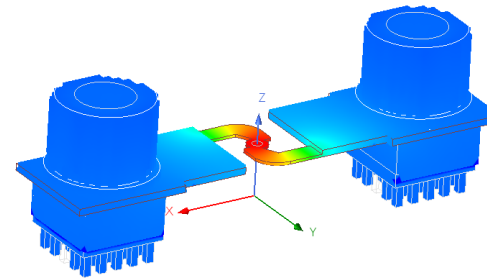
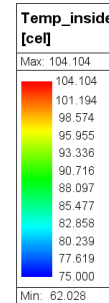
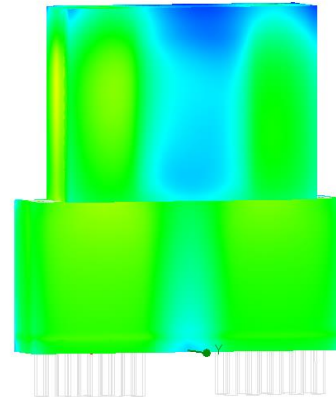
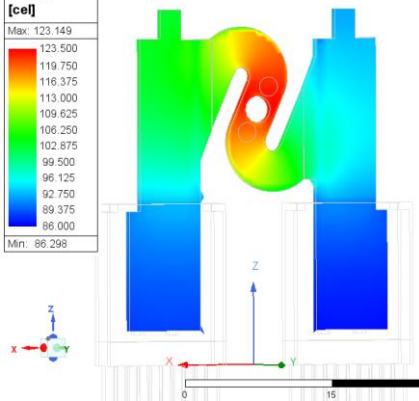
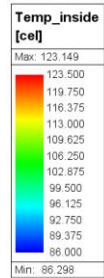
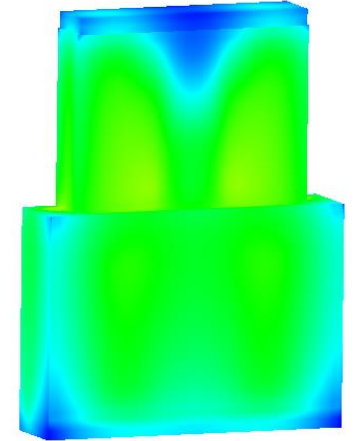
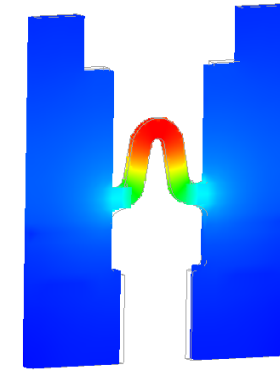
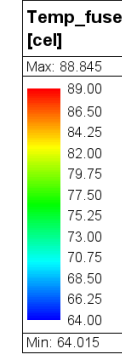
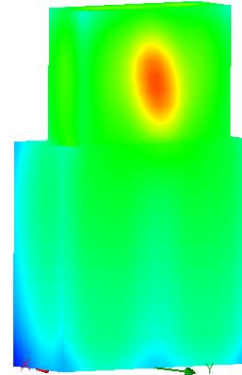
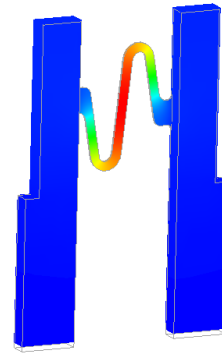
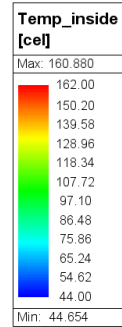
- Reduced copper thickness / layer count

Avoid product failure



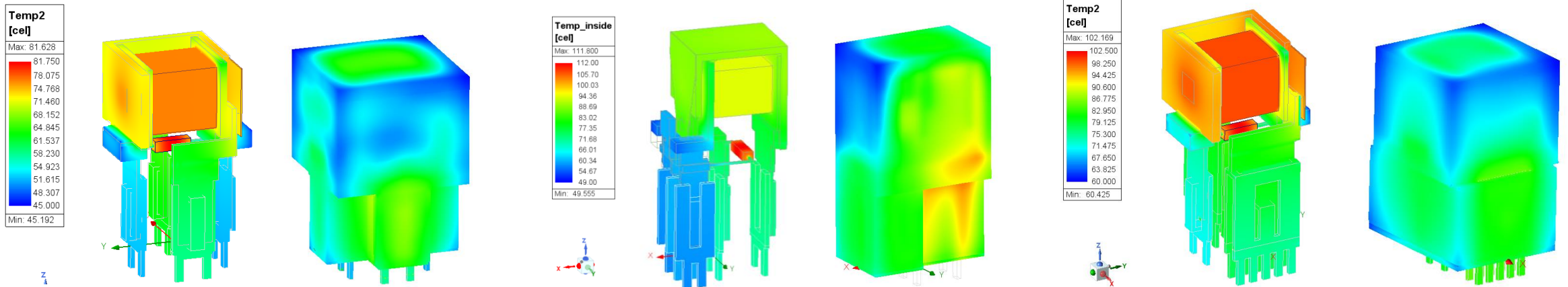
3. Thermo simulation EXAMPLES

- Littelfuse
 - MINI fuse
 - ATO Fuse
 - MAXI Fuse
 - MEGA Fuse



3. Thermo simulation EXAMPLES

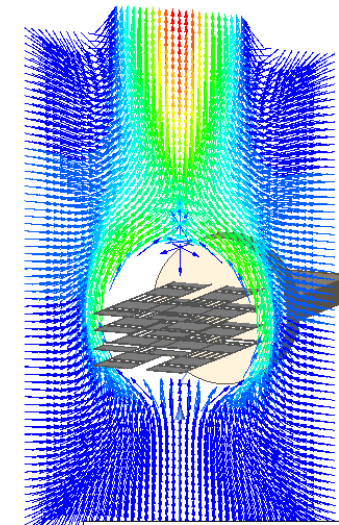
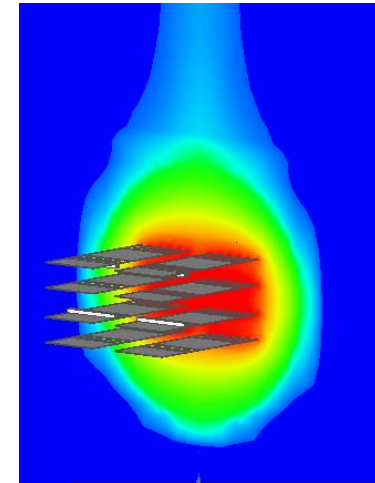
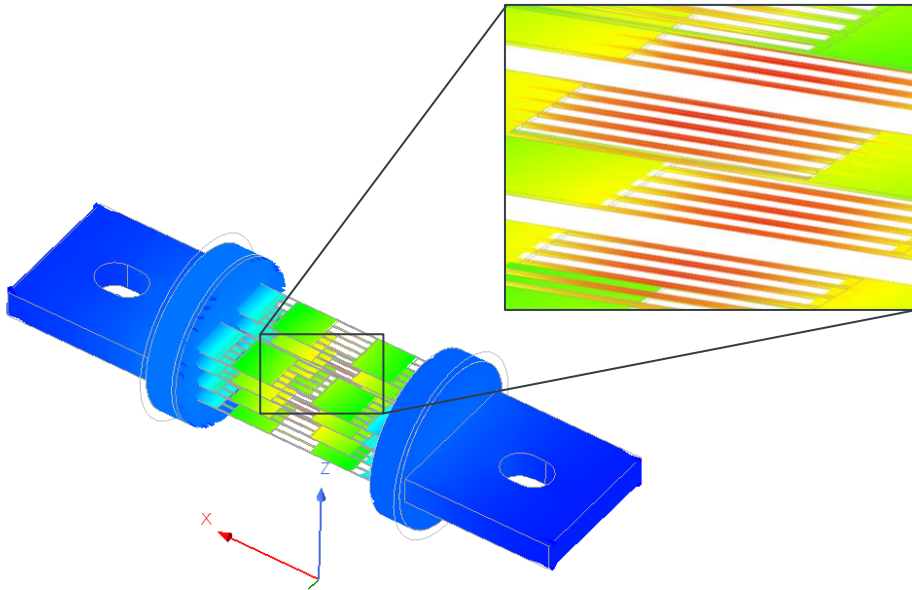
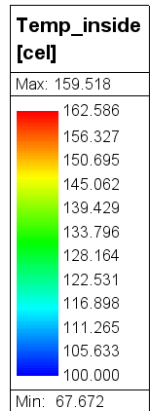
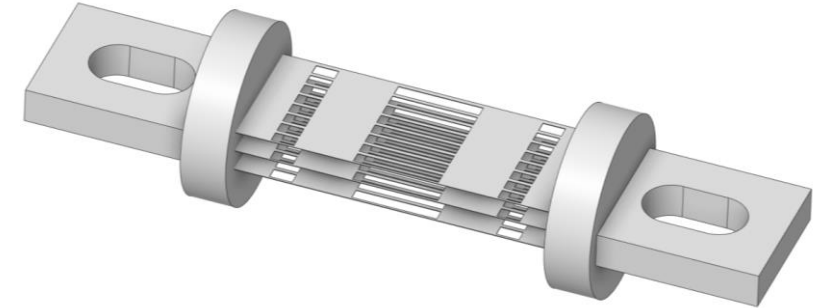
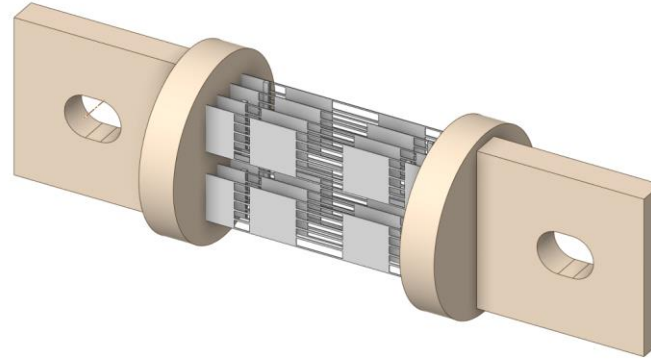
- Hongfa
 - Micro relay
 - Mini relay
 - Power relay



3. Thermo simulation EXAMPLES

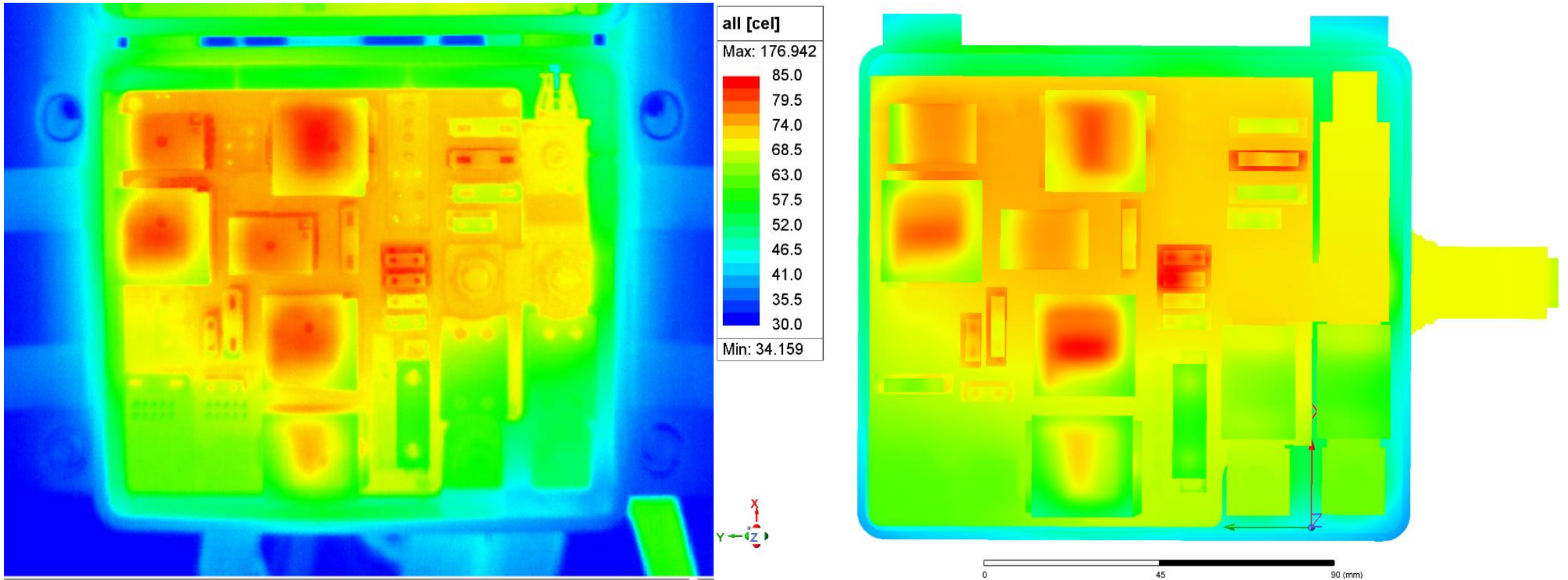
- Mersen
 - MEV100A300
 - MEV100J450
 - MEV100J600

3D models and material properties provided by Mersen



3. Thermo simulation

CUSTOMER PRODUCT – THERMO TEST VS SIMULATION LOW VOLTAGE





IF YOU HAVE ANY
PROJECT REQUEST,
PLEASE CONTACT US

Thank you



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YOUR CONTACT TO US



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