GREAT DESIGNS IN
STEEL

MECHANICAL FASTENING SOLUTIONS FOR BATTERY TRAYS

Eric Weber
Penn Engineering – New Product Development – PROFIL – North America
In collaboration with Dr. Amer Mahlme – New Product Development - Germany

2023

AGENDA

- A LOOK THROUGH THE 3 GENERATIONS OF EV ARCHITECTURE
- MECHANICALLY ATTACHED FASTENING
- WATER INGRESS PROTECTION
- PRESS HARDENED STEEL
- FASTENERS IN CLOSED SECTIONS
- KEY TAKEAWAYS

A LOOK THROUGH THE 3 GENERATIONS OF EV ARCHITECTURE

GENERATION 1 – SKATEBOARD

- Battery Tray underneath body frame
- Previous generation, still utilized

Rivian RT-1

Steel Cover

Extruded Aluminum Sides

Steel Bottom

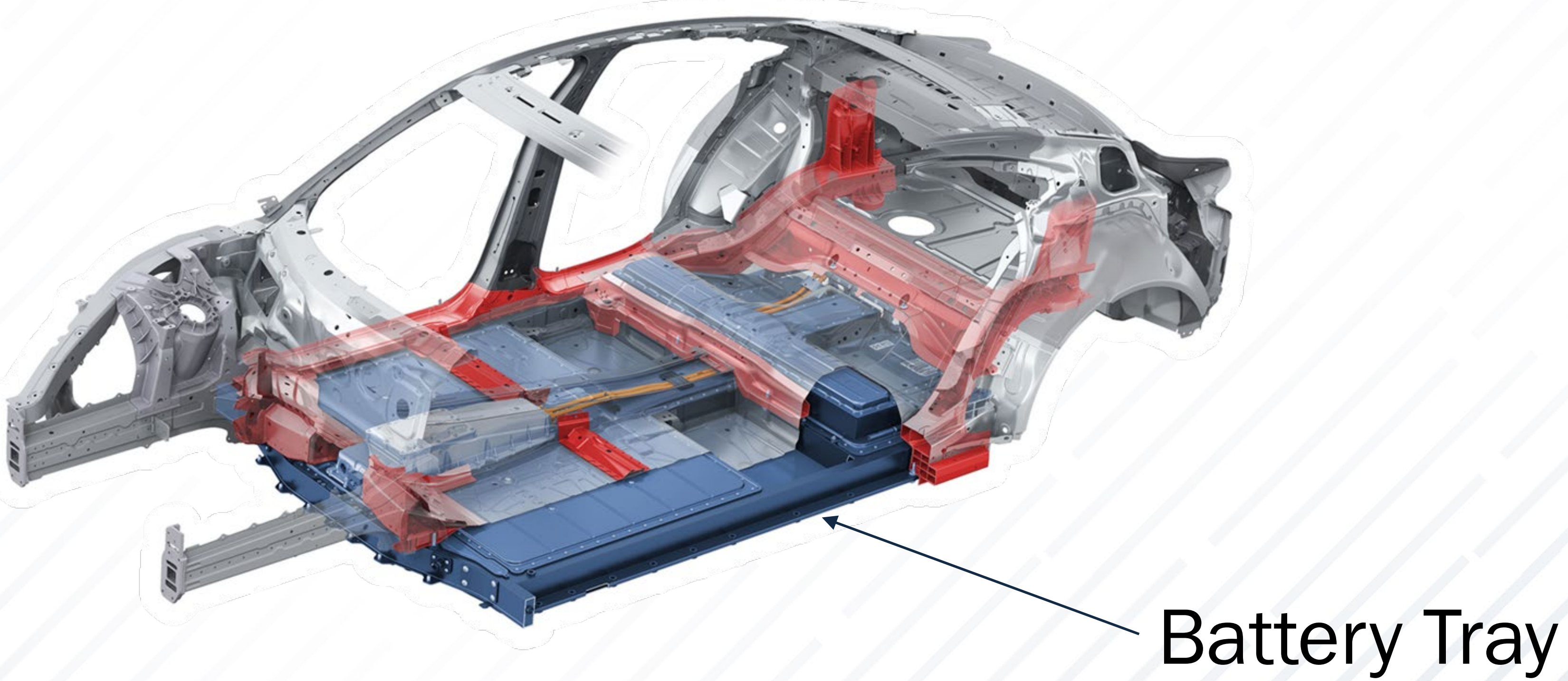
GENERATION 2 – STRUCTURALLY INTEGRATED

- Battery Tray integrated structurally with body frame
- Current Generation

Audi e-tron GT

Integration of the high-voltage battery in the body structure

02/21



GENERATION 3 – VEHICLE INTEGRATED

- Improvements in battery range/charging efficiency
  - Batteries infiltrating more spaces in a vehicle (i.e., Doors)
- Concern for occupant safety
  - Batteries becoming more structural
- Consideration for recycling of battery trays
- Material trends:
  - More optimization of cost
    - Increased use of high-strength steels
  - Lightweighting of components to continue
    - Increased use of alternative materials (aluminum, magnesium)
- Increased use in mechanically attached fasteners

FASTENING CHALLENGES

- Material Applications
  - New materials being introduced
  - Thinner Materials expected
- Ingress Protection
  - Requirements for ingress protection not fully being realized
  - Testing on a component level versus assembly level
- Application access
  - Long extrusions being used
  - Closed Access
- Load Bearing Capabilities
- Electrical conductivity

MECHANICALLY ATTACHED FASTENING

PENN ENGINEERING AND PROFIL

Global Leaders in Mechanically Attached Fasteners

THE PENN ENGINEERING ADVANTAGE

Technical Advisory and OEM and Tier
Global field engineering and direct sales engineers

Manufacturing
Global manufacturing capabilities in local markets

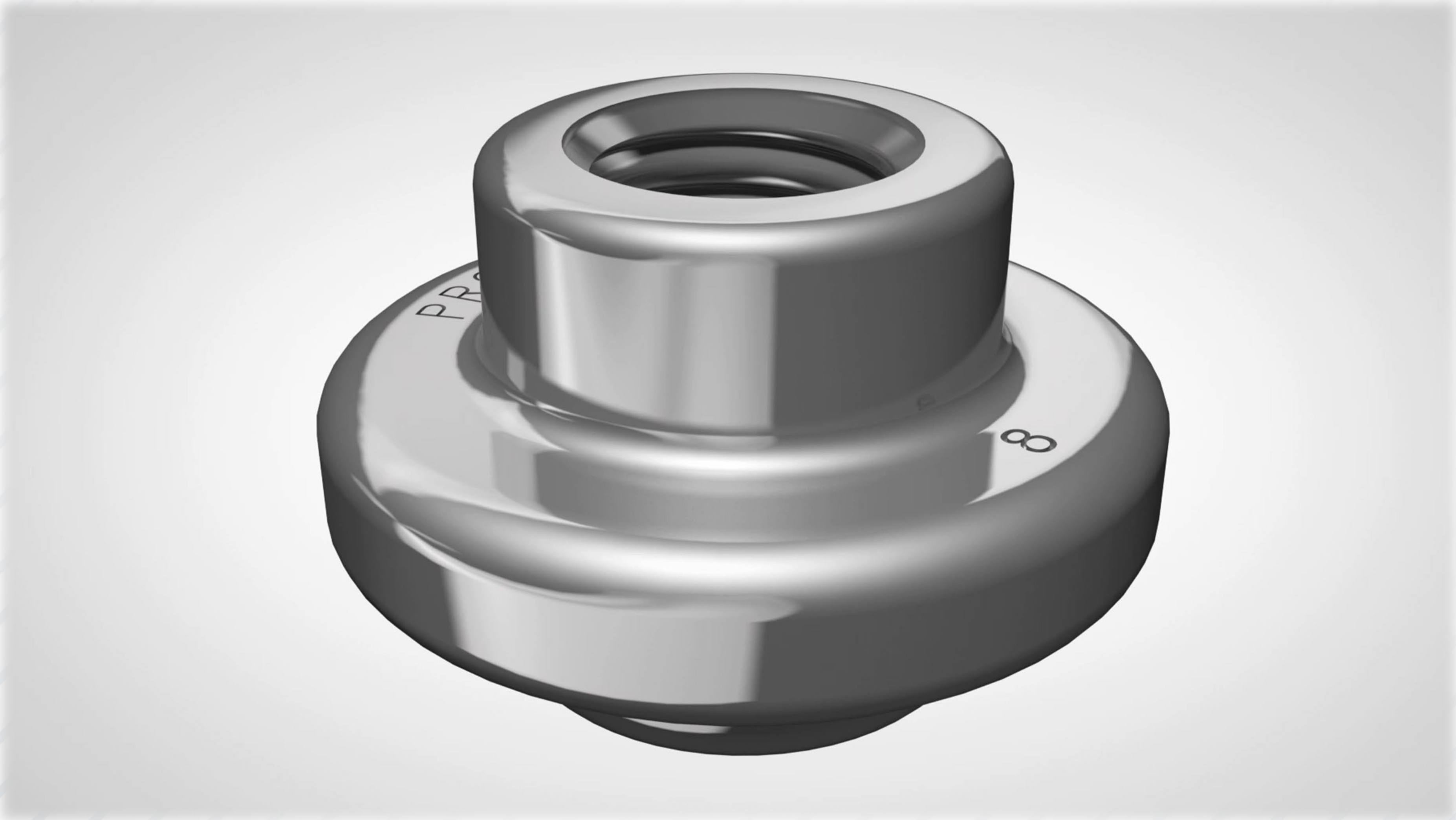
Application Engineering Support
Global application engineering experts and full test lab capabilities

After Sales Technical Support
Full, ongoing technical support and on-site training as required

MECHANICALLY ATTACHED FASTENERS (MAF)

	Riveting	Clinching	Self-Pierce
Internal Thread			
External Thread			

RIVETING



Link to video: https://www.profil-global.com/products/rnd/

CLINCHING

Link to video: https://www.profil-global.com/products/ebf/

SELF-PIERCING NUT

Link to video: https://www.profil-global.com/products/mhn/

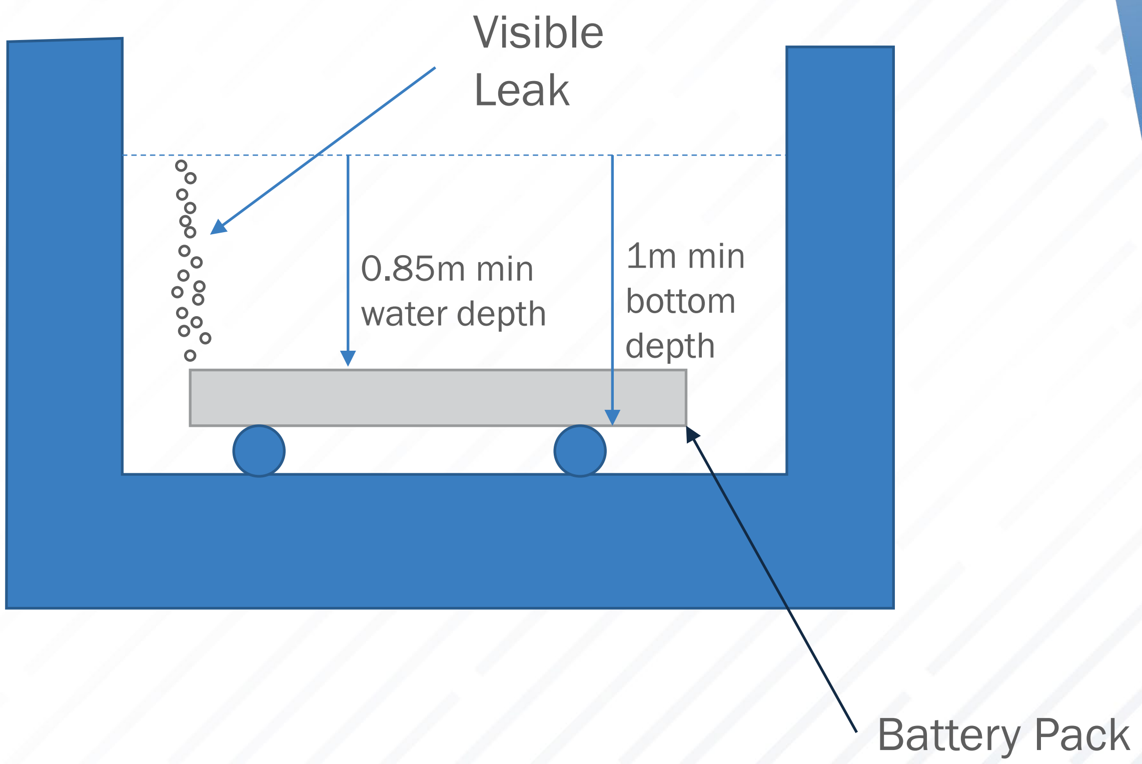
SELF-PIERCE STUD

Link to video: https://www.profil-global.com/products/sbf/

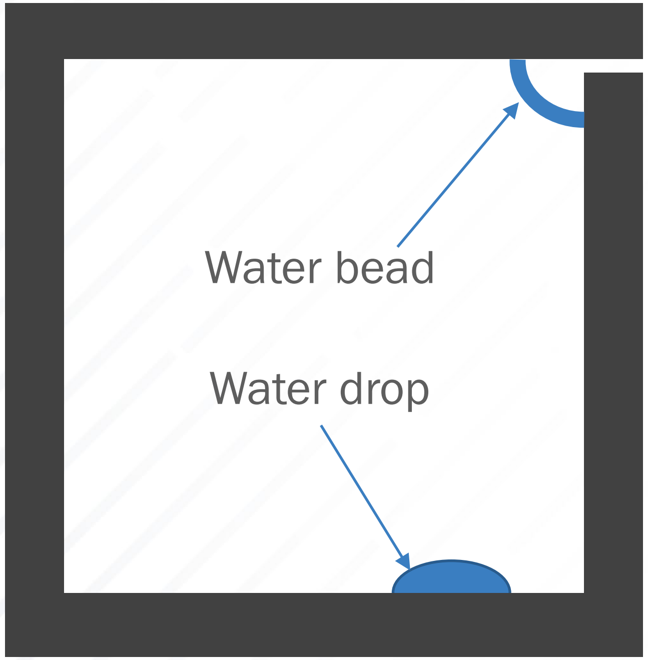
WATER INGRESS PROTECTION

INGRESS PROTECTION

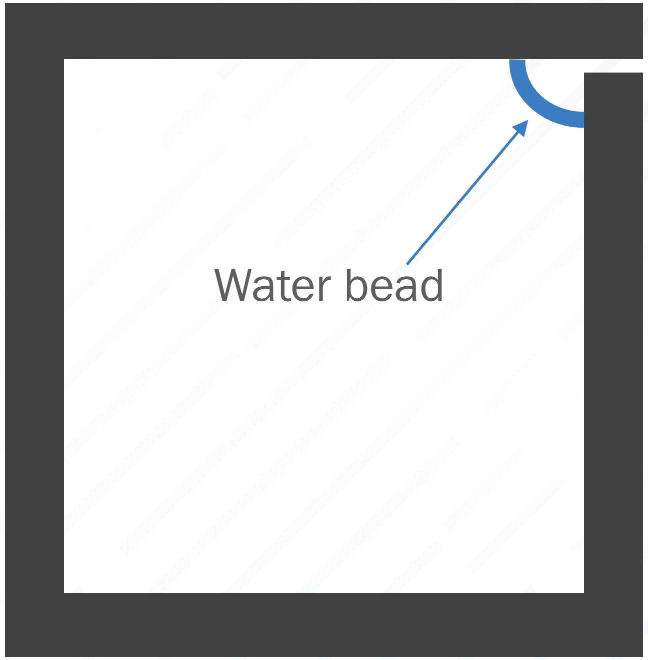
- Based on ISO 20653
  - IP67 –Temporarily submerged in water (30 minutes)
  - IP69K – Protection against high-pressure/steam jet cleaning
- Current process:
  - Submerge assembly in a large water bath
  - Wait 30 minutes and look for bubbles
  - Disassemble tested assembly
  - Look for water
- This process is quantifiable through counting bubbles expelled by the battery pack



CLARIFICATION OF FAILURE



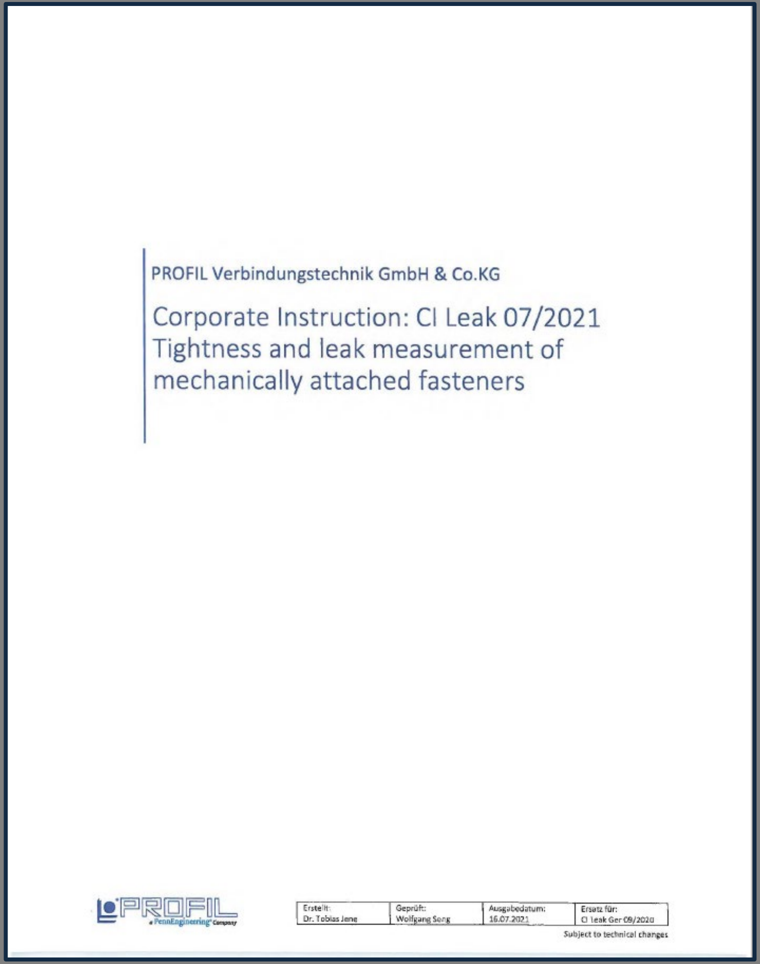
Failure



Pass

INGRESS PROTECTION

- Internally developed standard for leak testing MAF
- Developed with industry partner Inficon
- Quantifies leak resistance through vacuum method referencing Helium gas
- Available for industry use, please contact us



PROFIL Verbindungstechnik GmbH & Co.KG

Corporate Instruction: CI Leak 07/2021
Tightness and leak measurement of mechanically attached fasteners

PROFIL a PennEngineering Company

Erstellt:	Geprüft:	Ausgabedatum:	Ersatz für:
Dr. Tobias Jene	Wolfgang Seng	16.07.2021	CI Leak Ger 09/2020

Subject to technical changes

INGRESS PROTECTION

- Vacuum method referencing helium
  - Connect helium detector to outgoing port
  - Engage vacuum
  - Provide Helium to leak area
  - Read test value

Helium Mass Spectrometer
Leak Detector

Correlation between IP67 and IP69k and panel substrate:

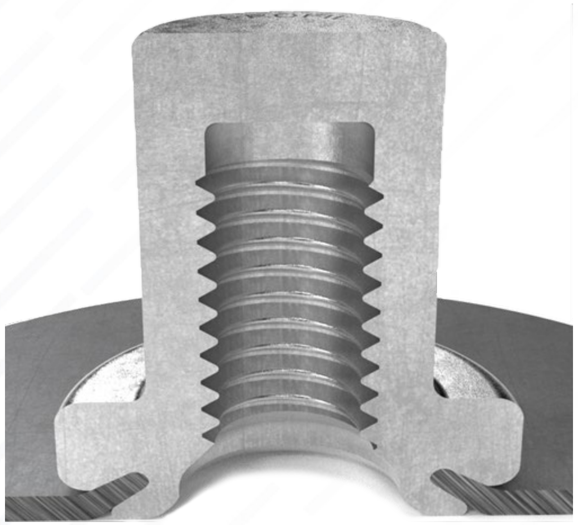
	IP67	IP69k
Steel	≈ $5 \cdot 10^{-3}$ mbar·l/s	≈ $1 \cdot 10^{-3}$ mbar·l/s
Aluminum	≈ $5 \cdot 10^{-5}$ mbar·l/s	≈ $1 \cdot 10^{-5}$ mbar·l/s

Demonstrations at our booth or appointment!

Meaning of leakage rates, Δp=1 bar:

Request	mbar·l/s	cm³/s	cm³/min	l/min	l/h	ml/min	sccm	Description
	10^{-0}	10^{-0}	$6 \cdot 10^{1}$	$6 \cdot 10^{-2}$	$3.6 \cdot 10^{0}$	$6 \cdot 10^{1}$	$6 \cdot 10^{1}$	Water tap drips
	10^{-1}	10^{-1}	$6 \cdot 10^{0}$	$6 \cdot 10^{-3}$	$3.6 \cdot 10^{-1}$	$6 \cdot 10^{0}$	$6 \cdot 10^{0}$	1 cm³ gas loss in 10 s
Watertight	10^{-2}	10^{-2}	$6 \cdot 10^{-1}$	$6 \cdot 10^{-4}$	$3.6 \cdot 10^{-2}$	$6 \cdot 10^{-1}$	$6 \cdot 10^{-1}$	Water tap does not drip
Oil-tight	10^{-3}	10^{-3}	$6 \cdot 10^{-2}$	$6 \cdot 10^{-5}$	$3.6 \cdot 10^{-3}$	$6 \cdot 10^{-2}$	$6 \cdot 10^{-2}$	<1 bubbles per second
Bacteria Proof	10^{-4}	10^{-4}	$6 \cdot 10^{-3}$	$6 \cdot 10^{-6}$	$3.6 \cdot 10^{-4}$	$6 \cdot 10^{-3}$	$6 \cdot 10^{-3}$	1 cm³ gas loss in 160 min
Gasoline Proof	10^{-5}	10^{-5}	$6 \cdot 10^{-4}$	$6 \cdot 10^{-7}$	$3.6 \cdot 10^{-5}$	$6 \cdot 10^{-4}$	$6 \cdot 10^{-4}$	1 cm ³ gas loss in 26 h
Gas Tight	10^{-6}	10^{-6}	$6 \cdot 10^{-5}$	$6 \cdot 10^{-8}$	$3.6 \cdot 10^{-6}$	$6 \cdot 10^{-5}$	$6 \cdot 10^{-5}$	1 cm³ gas loss in 12 days

INGRESS PROTECTION FASTENERS



RND Cap Nut

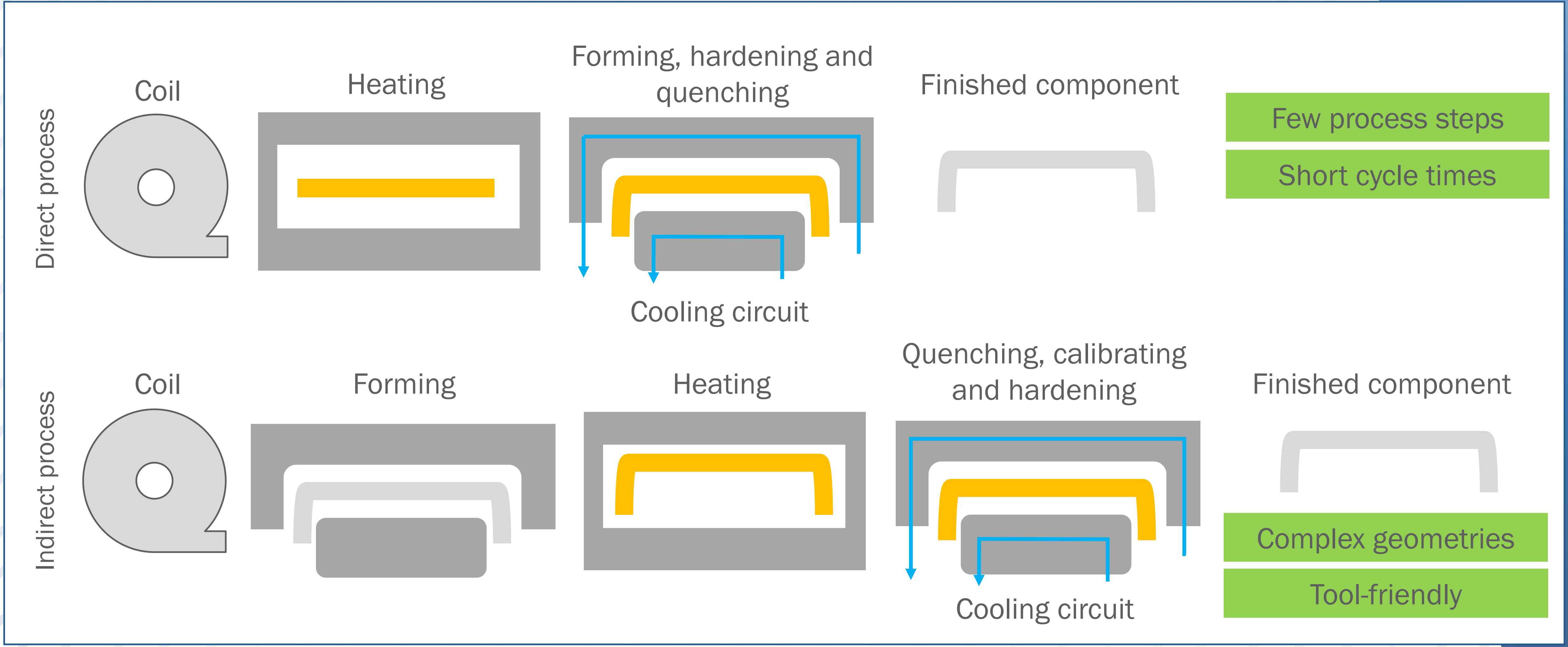
No special seals required

EBF - Watertight

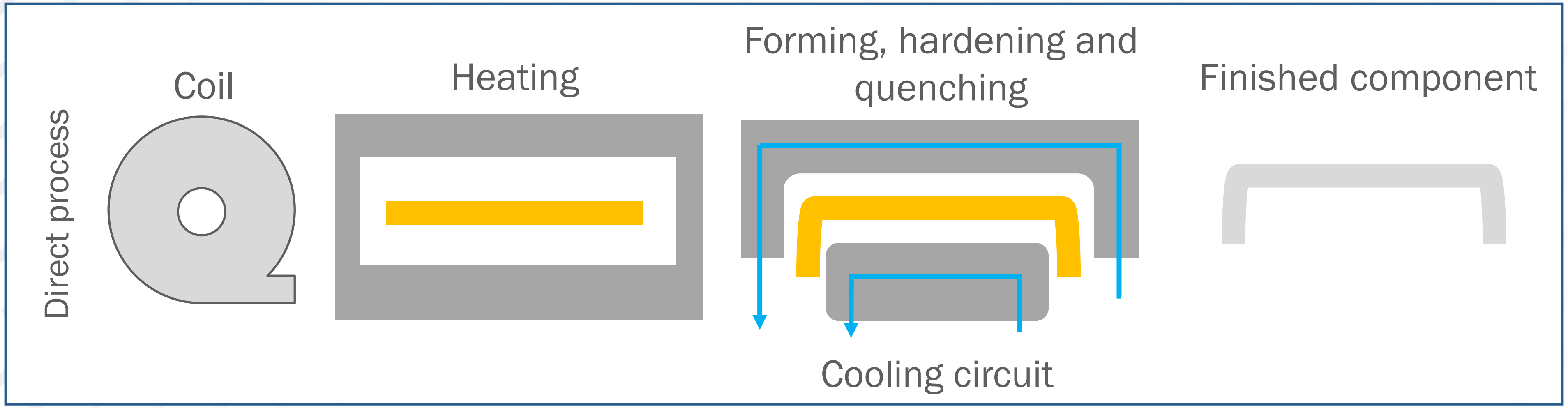
Clinch Stud

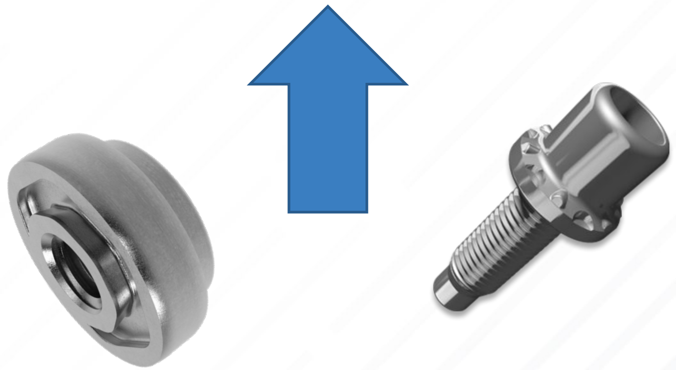
PRESS HARDENED STEEL

PRESS HARDENED STEELS



PRESS HARDENED STEELS - DIRECT



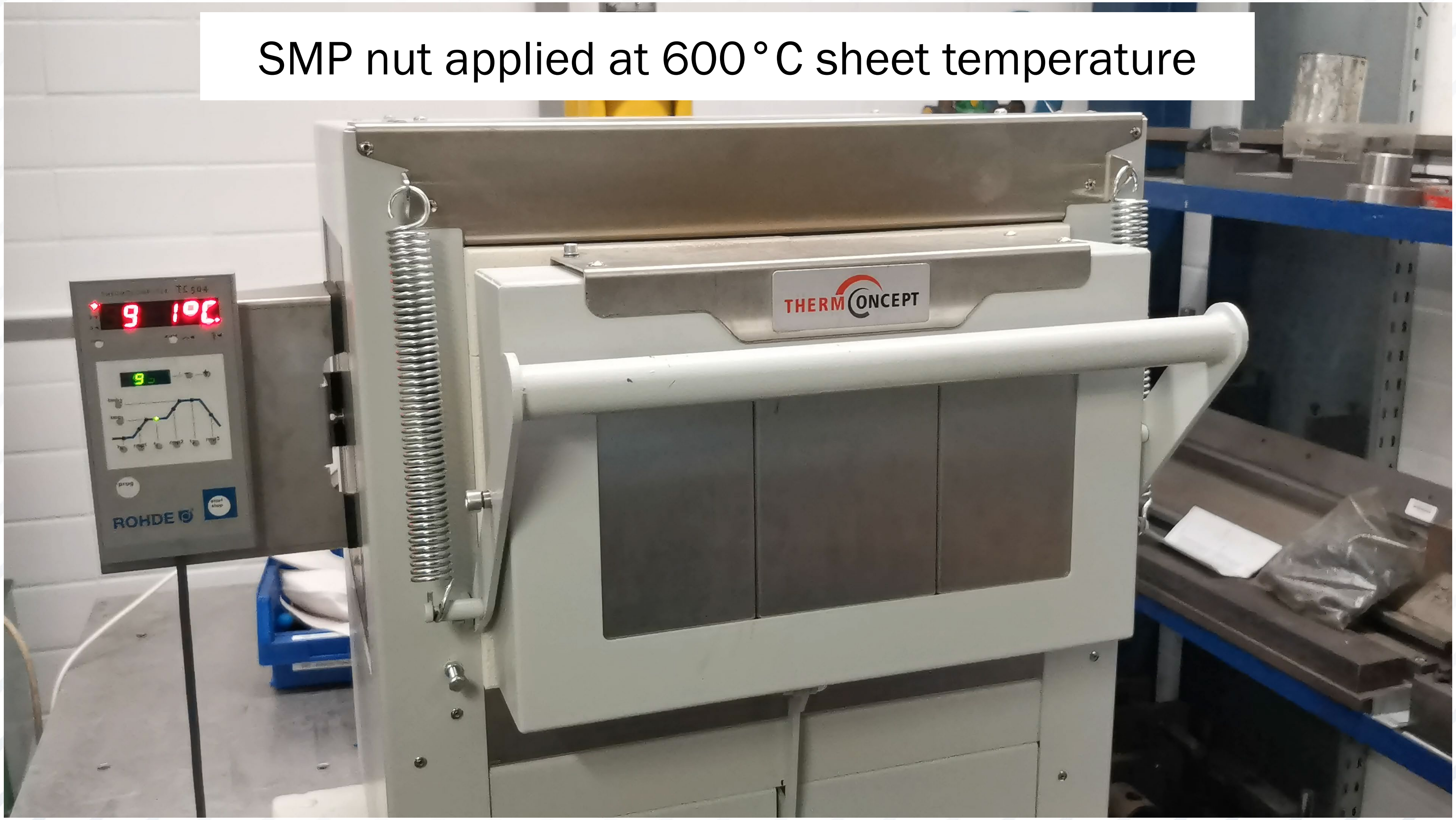


Steel is softest during forming stage and can easily self pierce

Fastener temperature elevates but does not temper due to cooling

PRESS HARDENED STEELS - DIRECT

SMP nut applied at 600 °C sheet temperature



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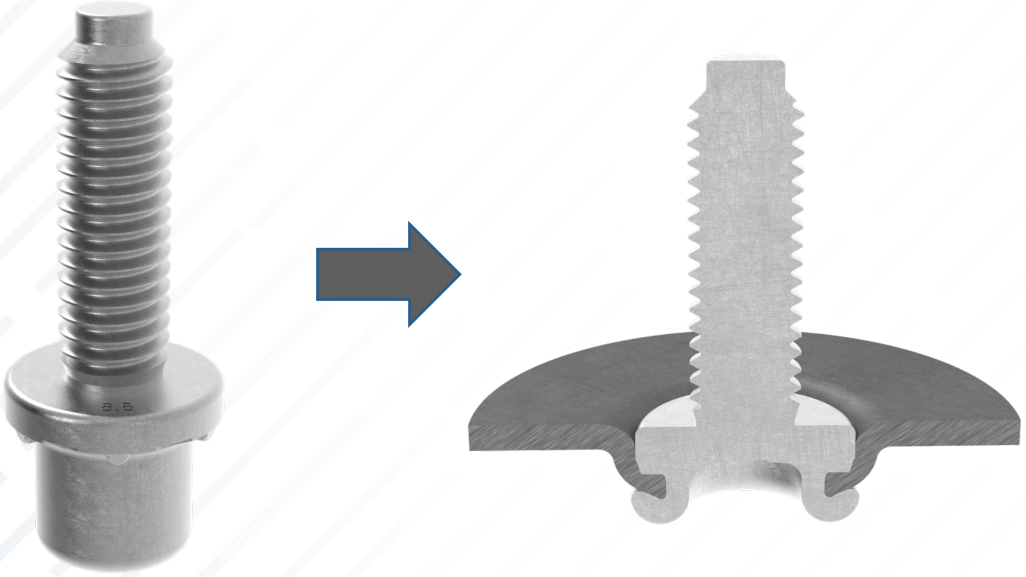
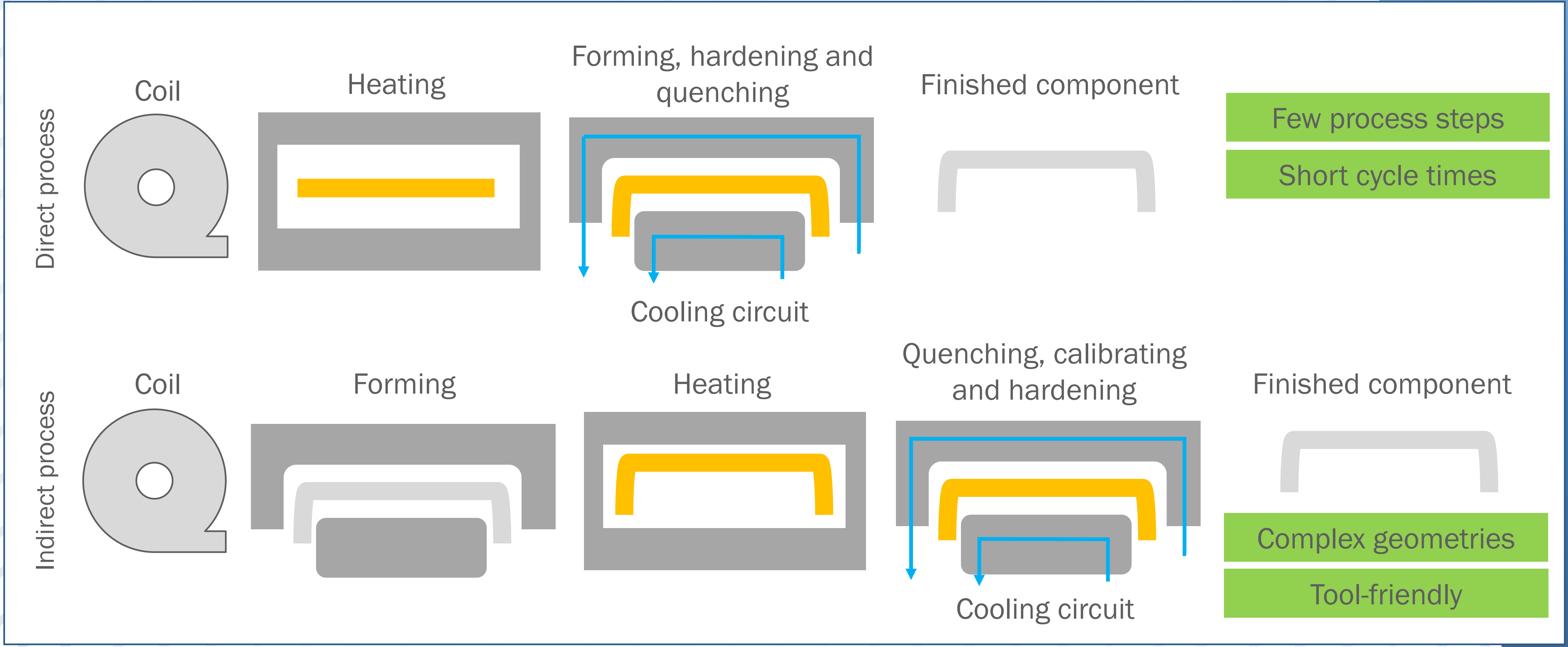


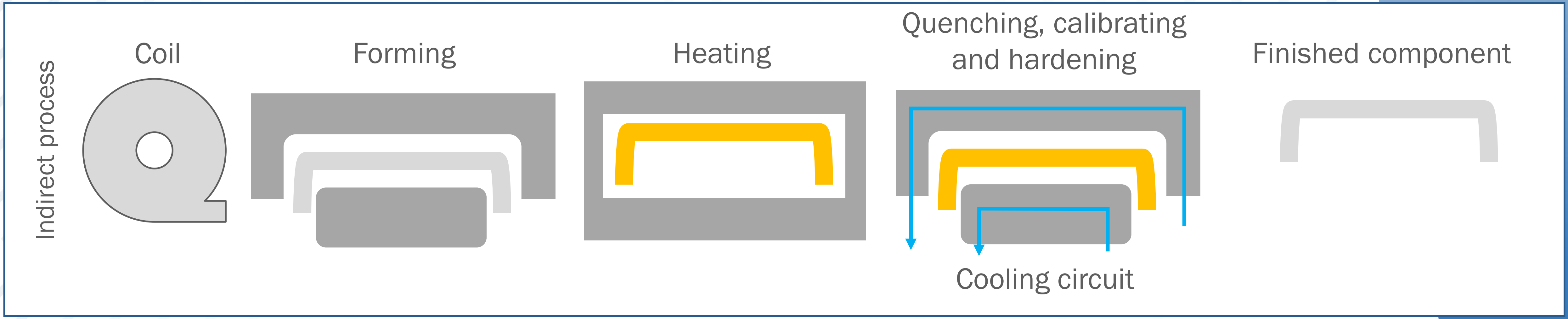
SBF

SMP

PRESS HARDENED STEELS



PRESS HARDENED STEELS - INDIRECT

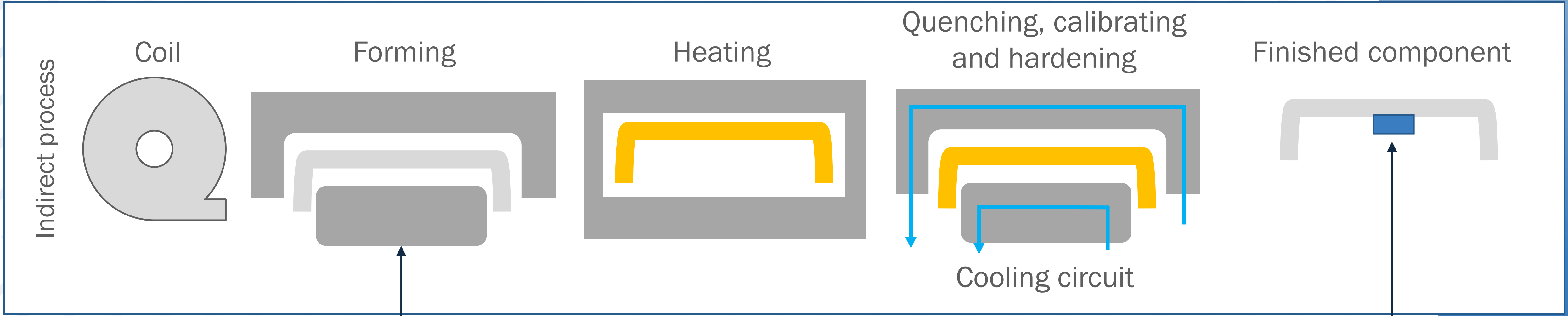


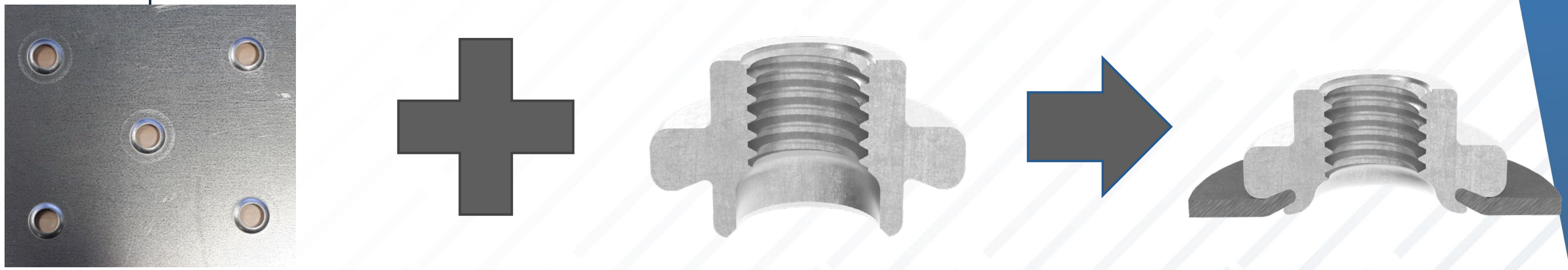
Uncontrolled fastener hardness

Fastener to be installed during quenching phase or through secondary process

Process not limited to fastener

PRESS HARDENED STEELS - INDIRECT





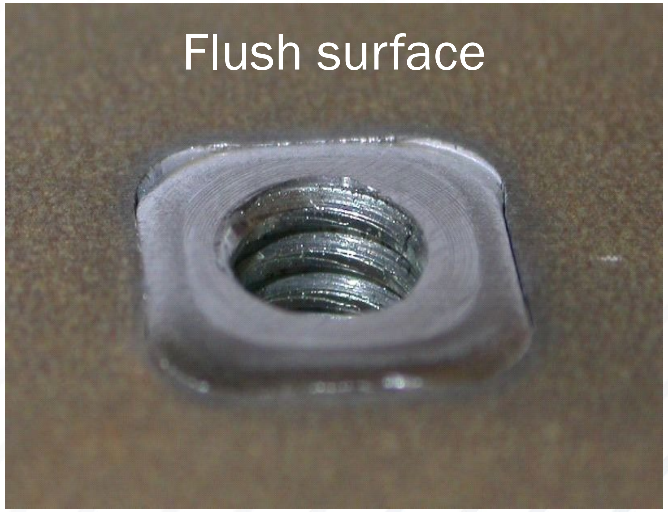
Fastener to be installed during quenching phase or through secondary process

Process not limited to fastener

PRESS HARDENED STEELS - INDIRECT

Specialized Fasteners designed

RND-S



Square RSE

FASTENERS IN CLOSED SECTIONS

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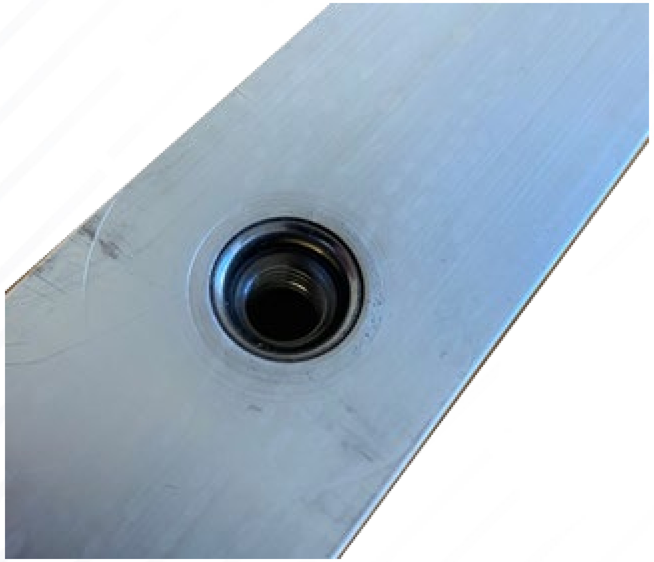

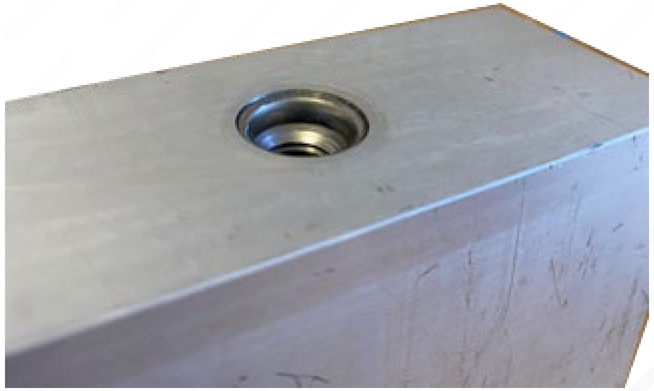

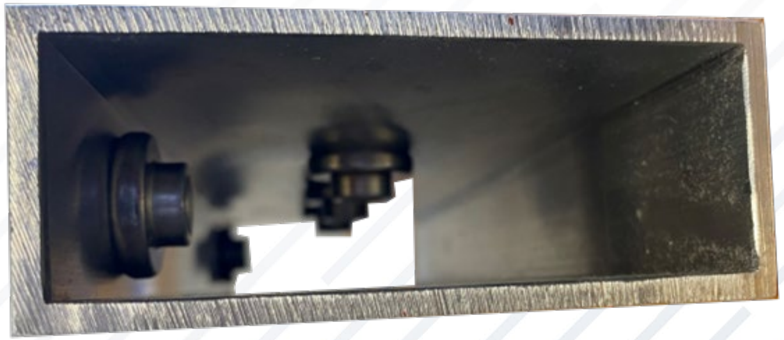

KEY TAKEAWAYS

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- EV architecture is evolving needing solutions from fasteners
- Mechanically attached fasteners are highly tailored solutions to many fastening problems
- Water ingress protection is possible through mechanically attached fasteners
- Attachment to a wide variety of materials is possible
- Applications in less accessible areas is possible, working with customers is key
- Development of Special Fasteners for Electrical Conductivity aids in application design

FOR MORE INFORMATION

Presenter

Eric Weber

Penn Engineering / PROFIL

eweber@pemnet.com

Collaborator

Dr. Amer Mahlme

Penn Engineering / PROFIL

Amer.Mahlme@profil.eu