PAT-Core

Enabling battery studies of unmatched quality

The PAT-Core is the worldwide patented, essential part of the PAT-Cell. It holds the electrodes under test in place and allows precise alignment of the cell stack.

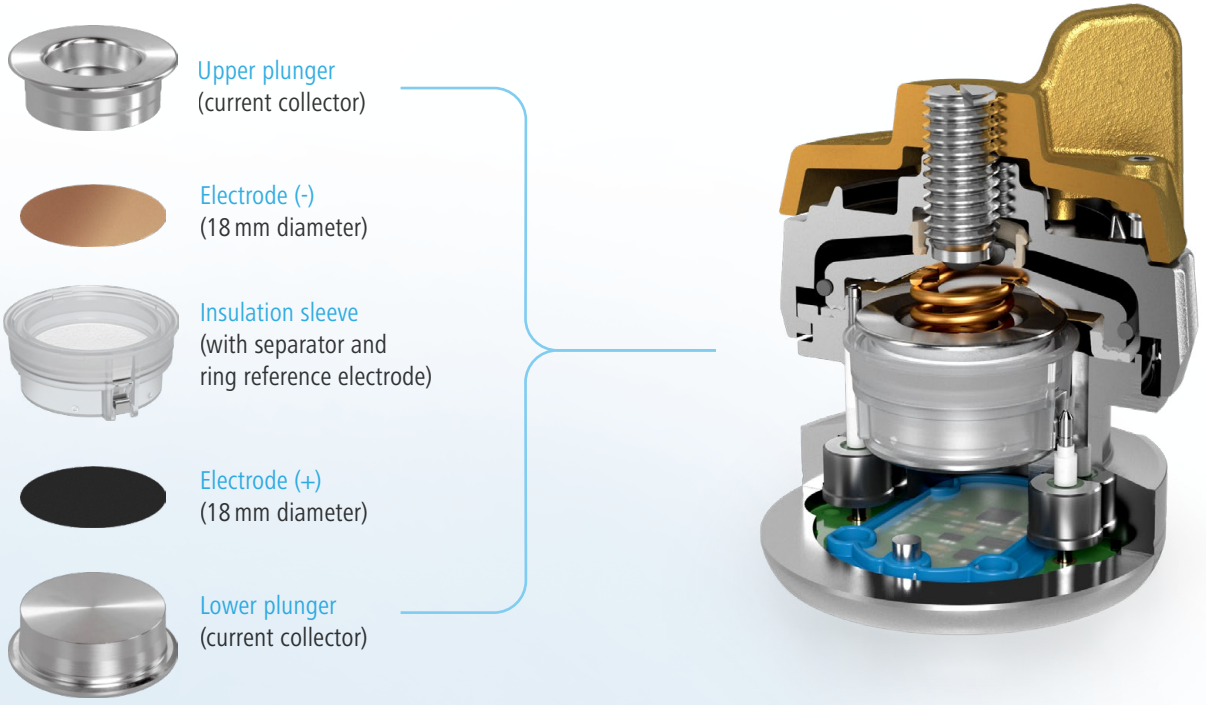
The well-defined geometry of the PAT-Core enables high-quality two- and three-electrode tests of Li-ion batteries and other battery materials, as well as supercapacitors. The easy assembly of the PAT-Core minimises the human factor in experiment preparation and even qualifies for robotic assembly. The standard PAT-Core comprises three components. The first part is a highly customisable insulation sleeve with a built-in separator and ring-shaped reference electrode. Different reference materials, such as lithium, sodium, or partly delithiated LFP, and various separator materials, such as glass fibre or microporous polyolefin, are available. The single-use concept reduces lab lead times and minimises the risk of cross-contamination.

The insulation sleeve is preassembled under a protective argon atmosphere at the EL-CELL factory to ensure consistent quality for reproducible battery tests. PEEK is an alternative insulation sleeve material; this way, we can also offer a reusable version for self-assembly.

The upper and lower plungers complete the PAT-Core and serve as current collectors. Battery researchers can choose from different materials: battery-grade aluminum and copper, reusable stainless steel and nickel, or precious metals such as gold or platinum for specific applications. The PAT-Core is suitable for aprotic and aqueous electrolytes. In addition, the PAT-Solid-Core and PAT-HT-Core variants offer solutions for specialized applications, such as the characterisation of solid-state batteries and high-temperature applications, further expanding the capabilities of the PAT-Core system.

Highlights of the PAT-Core

- High-precision concentric geometry of cell stack without manual alignment
- Modular concept adaptable for various configurations
- Long-term (>5000 hrs) measurements with three electrodes
- Easy, reproducible, and automatable assembly - with and without reference electrode
- All battery-grade materials available: Al, Cu, polypropylene
- Optionally reusable insulation sleeve and current collectors



PAT-Core Configurations

The PAT-Core components: Perfectly adjustable for your experiment

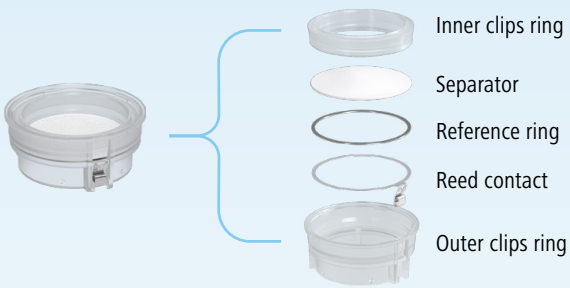
Different test cases require flexible cell configurations. PAT-Core components are available in various materials to perfectly match the needs of your investigation. **The examples shown below provide an overview of only the most common applications.** We continuously expand the PAT system to include new chemistries.

Configuration examples	Aprotic $LiPF_6$ based electrolytes	Aqueous supercap electrolytes	Aprotic high-temperature electrolytes
			
Lower electrode (+)	LCO / NCM / LFP..	Activated carbon	LCO / NCM / LFP..
Upper electrode (-)	Li metal / Graphite	Activated carbon	Graphite / LTO
Lower plunger	Stainless steel or aluminum	PEEK with gold as current collector	Stainless steel or aluminum
Upper plunger	Stainless steel or copper	PEEK with gold as current collector	Stainless steel or copper
Insulation sleeve	Insulation sleeve (PP), ready-to-use	Insulation sleeve (PEEK) for self-assembly	Insulation sleeve (PEEK) for self-assembly
Reference	Li metal	Activated carbon	Li metal
Separator	Whatman GF / A	Whatman GF / A	Whatman GF / A
Reed contact	Stainless steel	Gold plated stainless steel	Stainless steel

Insulation sleeves for the precise concentric alignment of your cell stack.

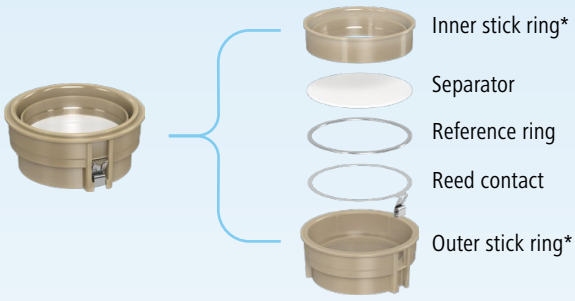
There are two types of insulation sleeves for the PAT-Core. The variant made of polypropylene is a single-use item with a built-in separator, ring reference, and reed contact. The single-use concept lowers lead times in the lab and is the perfect choice for high-throughput testing. On the other hand, the PEEK variant is reusable and optimal for higher temperatures (up to 200 °C). It is assembled before each test so you can quickly modify its components. It is the right choice for small-scale testing and the more unusual ideas.

Insulation sleeve (PP) for single-use



- No cross-contamination
- No cleaning or drying required
- Preassembled for lower lead time
- Operation temperature up to 70°C

Insulation sleeve (PEEK) for reuse



- Reusable PEEK component(*)
- Easily adaptable before each test
- Operation temperature up to 200°C

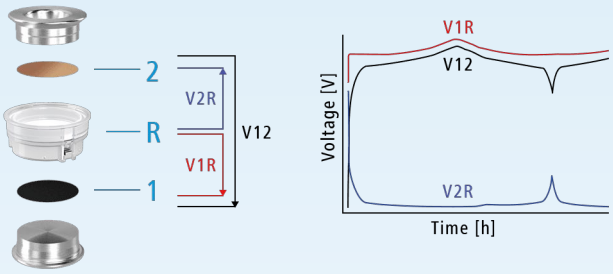
PAT-Core Configurations

Different separator materials for your test case

The following table shows our most common separator materials. Preassembled insulation sleeves using your separator materials are available upon request.

Separator types	**FS-5P** (Freudenberg Viledon FS 2226E + Gore Heerlen Solupor 5P09B)	**Whatman GF/A**	**Celgard QT17P2HX**
Thickness	220 µm	260 µm	16.5 µm
Material	PP fibre / PE membrane	Borosilicate glass fibre	PVDF / PP / PE / PP / PVDF
Porosity	FS: 67 % / 5P: 86 %	91 %	54 %
Wettability	Good	Excellent	Good
Resistance to dendrites	Good	Modest	Good
Ability for full cell cycle tests	Good	Good	Good
Ability for half cell cycle tests (vs. Li)	Good	Good	Modest
Ability for full cell EIS	Excellent	Excellent	Excellent
Ability for single electrode EIS	Modest	Good	Modest

The power of testing with a reference electrode



By monitoring the cell voltage and cell current of the battery, you can learn a lot about the performance and aging of the battery as a whole. However, a battery comprises two electrodes connected in series: cathode and anode.

Which of the two is the bottleneck for charge transfer? Which electrode is dying off first? Using a reference electrode is the most convenient way to answer these questions.
The insulation sleeve of the PAT-Core is available with different built-in reference rings and separators. We consider insulation sleeves with Li metal reference and a glass fiber separator the most robust and versatile solution for Li-ion-based systems. Many variants of the insulation sleeve are available for other battery chemistries, including Mg, Na-ion, and supercapacitors. When used with a battery tester like the PAT-Tester-i-16, the reference electrode enables you to measure the electrochemical properties of both electrodes at the same time.

PAT-Core Components

The PAT-Core is a modular and interchangeable system that meets the requirements of almost any test scenario. Its components are compatible with all PAT series test cells that utilize the standard PAT-Core design. Custom materials are available upon request.

Separators

FS-5P

Double layered separator:
PP fibre + PE membrane

Whatman GF/A

Borosilicate glass fibre

Celgard QT17P2HX

PVDF / PP / PE / PP / PVDF

Customized

Provided by customer

Reference rings

Lithium

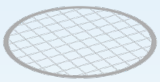
Aluminum

Activated Carbon

Magnesium

Sodium

LFP, partly delithiated



Stainless steel (Mesh)

Reed contacts

Stainless Steel

Gold

Insulation sleeves

PP

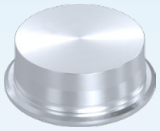
- Single-use
- Preassembled

PEEK

- Reusable
- Heat resistant (up to 200 °C)
- For self-assembly

Current collectors: Plungers and discs

Aluminum

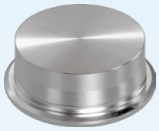


- Single-use
- Battery grade material (Al 99.5, EN-AW-1050)

Copper

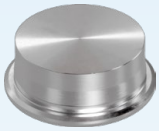
- Single-use
- Battery grade material (Cu 99.9, E-CU 58)

Stainless steel



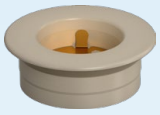
- Reusable
- Stainless steel (316L, 1.4404)

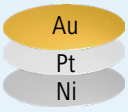
Nickel



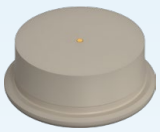
- Reusable
- Nickel (Ni > 99 %)

PEEK with gold pin





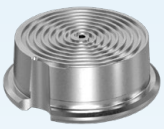
Current collector discs



- Reusable
- Corrosion resistant

Stainless steel / Nickel

- With perforated plate for gas analysis



- With flow field for time resolved gas analysis