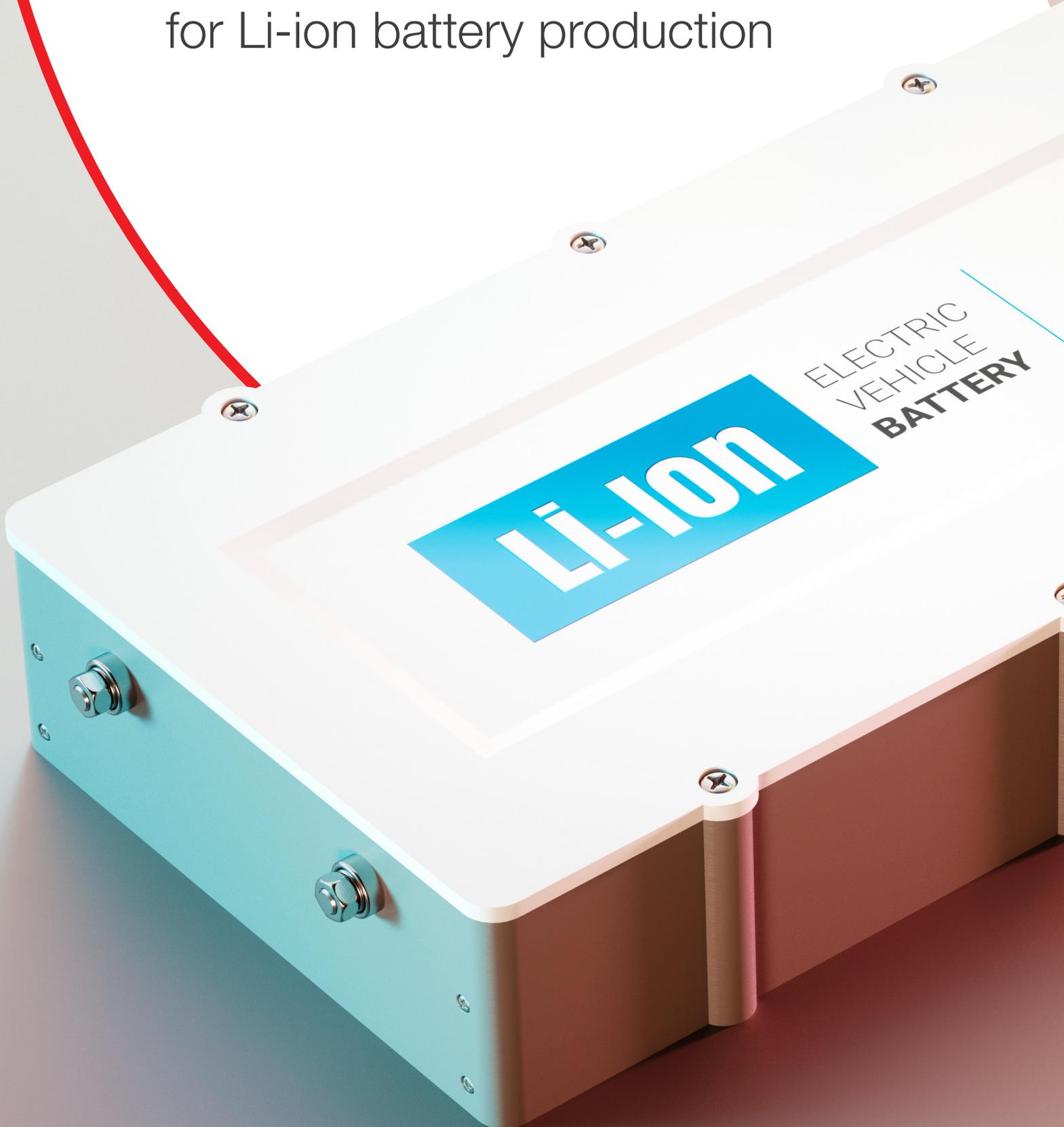




Innovative vacuum solutions

for Li-ion battery production



Integral to production:

Leybold offers perfect products for each step of the

With the growing importance and emergence of new solutions for energy storage and mobility, Li-ion batteries become more and more relevant. Thanks to the increasing demand, research in the field of Li-ion batteries has been intense, leading to significant technology improvements regarding capacity, power and lifetime of the batteries.

Li-ion batteries are one important step on our way towards green use of energy. They are being used as energy storage solutions for renewable energy e.g. produced by wind turbines or solar panels. For our way towards sustainable mobility, Li-ion batteries are built in cars, trucks, buses or scooters for private or public e-mobility.

Starting with the fabrication of the anode and cathode material, requiring active material, solvents, binders and additives, and the copper and aluminum foils, the production process of a Li-ion battery cell consists of various steps. Each step has its specific requirements and particularities, which at the end of the process define the quality of the final product, the Li-ion battery.

Vacuum plays an essential role in the battery cell production. Looking at the different production steps of a Li-ion battery, vacuum is needed:

- To enable the process
- To deliver purity in process
- To achieve process efficiency
- To produce a high-quality product

Without vacuum, some process steps would not even be possible. In other steps, vacuum is needed to enhance purity, quality and/or safety. Finally, a vacuum leak test can proof the battery quality in the last production step to ensure a high product lifetime.

Leybold offers the perfect vacuum products for each process step. With detailed application and product expertise, we support in the selection of the right vacuum product or system for your specific process requirements.

Li-ion battery cells can either be built in the form of a pouch cell with a soft cover, or in a hard cover in a cylin-

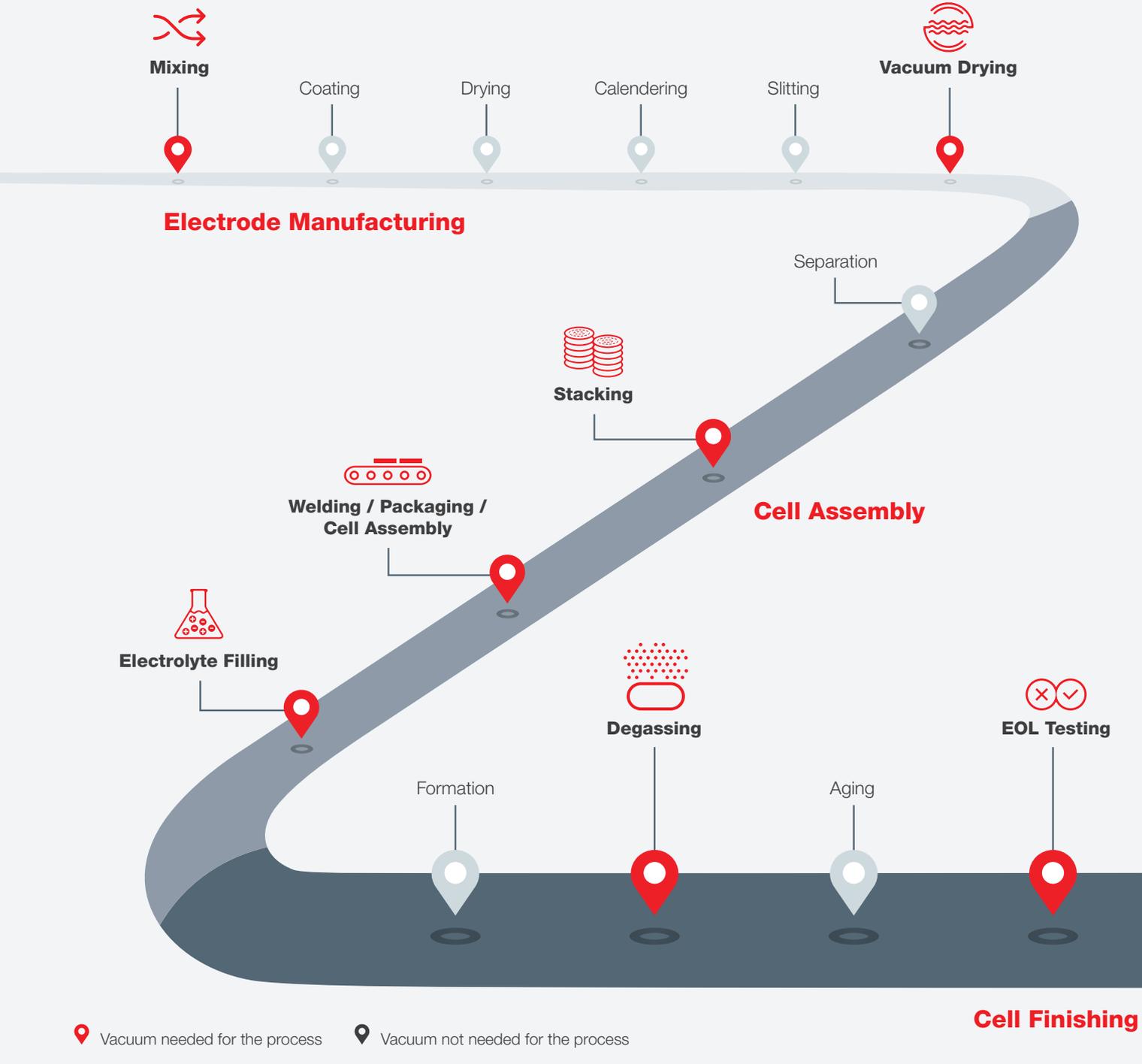


Li-ion cell production process

drical or prismatic form. The production process for the pouch cell differs from the process for cylindrical/prismatic cells due to the different housing characteristics.



The main steps of every battery production are the electrode manufacturing, the cell assembly and finally the cell finishing.



Vacuum solutions in the cell production

In the different steps of the battery production process, vacuum is relevant and essential for a high battery quality. Depending on the vacuum requirements and process challenges, different vacuum pumps are suited.



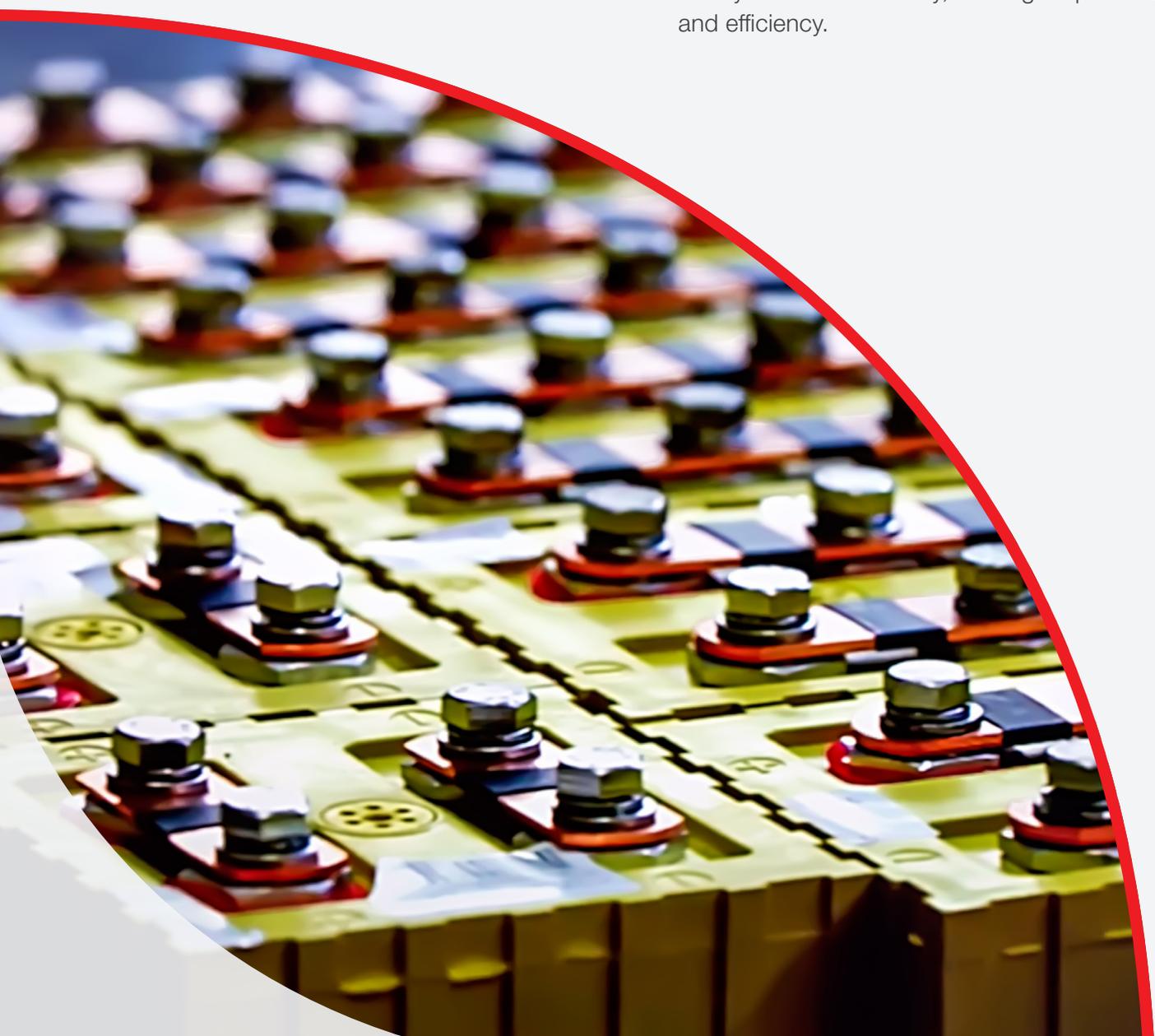
Mixing

To prevent gas inlets, reach homogeneity, viscosity and purity of the slurry, the mixing process ideally takes place under vacuum conditions. The mixer is therefore equipped with a vacuum pump. The vacuum degassing leads to a high-quality slurry in terms of homogeneity and purity.



Stacking

The correct positioning of the before assembly is ensured by vacuum grippers. In this step, the anode, separator and cathode are stacked into the electrode sheets in a repeated cycle. The exact positioning of the sheets has a high impact on the later product quality. To achieve an exact stacking, vacuum grippers are used. These are mostly connected to a central vacuum system in the facility, leading to process stability and efficiency.





Vacuum Drying

After the electrodes are rolled and slit into smaller electrode bands, these coils need to be dried. For a high-quality battery, it is essential to remove all humidity and solvent residues. The drying process uses heat and vacuum to remove all residues which weaken the battery capabilities. Vacuum plays an essential role during the drying process because it enables a much lower residual humidity of the electrodes.

This process step requires a robust and reliable vacuum system. The vacuum pumps need to withstand humidity and solvent traces. Furthermore, purity in process is a must, so dry compressing pumps become relevant to avoid backstreaming of oil particles towards the coils. The vacuum drying can either take place in a batch dryer or an in-line dryer.



Packaging (Pouch)

Before the cell stack can be inserted into the pouch housing, the pouch foil needs to be formed. This forming is typically done via deep-drawing of the pouch foil under vacuum. Vacuum-assisted deep drawing is an efficient solution and leads to stable results.



Degassing

During formation, the pouch cell's gas bag fills up with gas. In a final step, this gas bag needs to be degassed and removed. For removing the gas bag, a clean and dry environment is essential to avoid backstreaming of contaminants into the pouch cell – the degassing and sealing takes place under vacuum. To maintain a humidity- and oil-free atmosphere dry compressing pumps are needed.



Electrolyte Filling

The electrolyte filling of the battery cells, both pouch and hard cells, is done under vacuum to ensure an even dispersion of the electrolyte within the cell. Afterwards, the pouch foil is sealed under vacuum. Working pressure during the filling is typically ≤ 0.01 mbar. The vacuum pump must withstand electrolyte traces which might be dragged into the pump. Purity in process is essential, so dry compressing oil-free pumps are a must. To deal with potentially explosive gas-mixtures, we can offer ATEX rated pumps to ensure process safety at all times.



EOL Testing

For quality and safety reasons, the absolute tightness of the final battery is essential. That's why in the final step, a leak test is performed to ensure a tight battery, leading to a long lifetime and high product quality. For this step, we offer different versions of helium leak detectors for a reliable and non-destructive leak test that can detect even very small leaks.

Our vacuum expertise - your advantage

For the whole battery production process, we offer the perfect vacuum solution. Depending on the specific and individual process requirements, different pump types and configurations can be chosen.

Oil-sealed vacuum pumps

For battery cell production steps not requiring a completely oil-free system, we offer highly robust and reliable oil-sealed pumps with a perfect cost-performance ratio. Get the most out of your vacuum pump with exceptional robustness and save on costs with our all-time favourites.

SOGEVAC

Price attractive slurry degassing

- Rugged design: Benefit from long maintenance intervals and quick & easy service handling
- High water vapor tolerance: Don't worry about humidity when mixing wet slurries
- High pumping speed optimized for bigger mixer volumes
- ATEX certified options: Highest safety when processing flammable solvents



VACUBE

Most efficient central vacuum solution for cell production lines

- Benefit from one vacuum solution for all your rough vacuum applications
- Smart pressure control – operation exactly at set-point
- Optional control system for multiple parallel installed pumps to cover higher pumping speed demand
- Unique load depending speed control – vacuum on demand
- Bench mark energy saving potential
- Pumping speeds up to 1650 m³/h



Instrumentation

PHOENIX

Highest leak detection accuracy in EOL testing for safe battery cells

- Fastest measurement sequences: Save time with quickest measurements
- Superior helium sensitivity in all test modes for an extraordinary measurement accuracy
- Most reliable measurement system with an exceptional long-life ion source
- Intuitive operation - convenient touch screen and intelligent test functions



Pressure Gauges

Highly reliable gauges for every step of the battery cell production process

- Direct, gas type independent pressure measurement: CERAVAC capacitive gauges with highest precision and suited even for corrosive process gases. DI/DU capacitive and piezo sensors with a wide measurement range and excellent corrosion resistance.
- Indirect, gas type dependent pressure measurement: THERMOVAC Pirani gauges with fast response and high accuracy - and optimized price-to-performance ratio. PENNINGVAC cold cathode transmitters for a wide measurement range - even in rough applications.



Dry compressing vacuum pumps

In battery cell production, purity is essential. Dry-compressing pumps are oil-emission free and avoid the potential risk of oil-migration into the process chamber, by this ensuring highest process quality of the vacuum system. Your advantages? Save time and cost with minimized maintenance and optimized service life plus ensure a high quality battery cell.

DRYVAC

Innovative pump for drying, electrolyte filling and degassing

- Benchmark for energy efficiency, noise and compactness
- Hermetically tight design prevents gas from escaping the pump: Profit from highest safety when working with hazardous gases
- ATEX certified options: Highest process safety when working with flammable electrolytes
- Dry compressing screw principle offering highest process robustness, longer up-times and less maintenance: Save on time and cost
- Pumping speed 200, 300, 450, 650, 1600 m³/h



VARODRY

Dry screw pump for mixing, degassing, drying and electrolyte filling

- Reduce your energy costs with the best-in-class power consumption
- 100% oil-free design for highest process quality
- Dry compressing screw principle offering highest process robustness, longer up-times and less maintenance: Save on time and cost
- Pumping speed 65, 100, 160, 200 m³/h



LEYVAC

Highest purity during drying, electrolyte filling and degassing

- Dry compressing screw principle offering highest process robustness, longer up-times and less maintenance: Save on time and cost
- Hermetically tight design prevents gas from escaping the pump: Profit from highest safety when working with hazardous gases
- Pumping speed 80, 140m³/h



CLAWVAC

Premium claw technology for stacking and cell packaging

- Dry compressing claw pump optimized for rough vacuum applications: Profit from best rough-vacuum energy efficiency and save on energy cost
- Air-cooled and reliable
- Pumping speed 65, 150 and 300 m³/h



SCREWLINE

High process safety in drying, filling and degassing with ATEX versions

- Dry compressing screw principle offering highest process robustness, longer up-times and less maintenance: Save on time and cost
- 100% air cooled
- Pumping speed 630 m³/h
- ATEX certified options: Ensure a high process safety when dealing with flammable solvents and electrolytes



RUVAC

Boosts pumping speed for fast pump down of large drying chambers

- Dry compressing technology: Benefit from purity in process for a high battery cell quality
- Best fit selection with multiple variants for your application
- Variable speed drives for best deployment and adaption into your process: Save on energy costs and stay flexible along the process





Traditionally innovative

Leybolds customer proximity and application oriented product developments have been key to success since 1850. The range of products includes vacuum pumps as components, standardized or even customized solutions, as well as instruments to measure and control vacuum. Leybold as a major supplier in the lithium-based secondary cell business supports your demand in production processes and assures essential benefits.

- Performance
- Process uptime
- Throughput
- Reliability
- Efficiency

Leybold vacuum solutions offer more than state-of-the-art technology.



Leybold Service

Expert and reliable partner

Maintaining your uptime and reducing the risk of production downtime is critical. Wherever you are, Leybold is there to support you as your vacuum service partner. Our Field Service team and our fully equipped Service Technology Centers are at your disposal.

Your expectations:

- Continuously running production
- Reliable vacuum performance
- Longer lifetime for your vacuum pumps

Our solutions:

- Complete portfolio of service products to ensure your vacuum pumps are regularly maintained
- Long lasting partnership solutions to fully take care of your vacuum system
- Unrivalled vacuum expertise by highly trained vacuum specialists
- Professionally equipped Service Technology Centers which are able to handle even pumps from contaminated processes
- Laboratories that can perform gauge calibration and measurement instruments with the highest accuracy and precision