

HOW INDUSTRIAL GAS IS POWERING THE FUTURE OF ELECTRIC VEHICLE BATTERIES





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The Role of Gas in EV Battery Manufacturing

Electric vehicles (EVs) marked a pivotal shift toward a more sustainable future, promising cleaner, more efficient alternatives to fossil fuel-powered cars. At the heart of this transition, and these vehicles, are lithium-ion batteries. These batteries have become powerhouses of the energy storage industry, and growing demand for them is driving advancements in manufacturing.

Industrial gases play a fundamental role in manufacturing lithium-ion batteries, influencing the efficiency, safety and environmental impact of production while ensuring the integrity and performance of the batteries themselves.

At <u>Airgas</u>, we're honored to be instrumental in these critical processes, thanks to the incredible capabilities of industrial gases like nitrogen.

In this eBook, we'll dive into the many roles of gases throughout the battery ecosystem, in particular the battery component and cell manufacturing sectors. Join us as we uncover the importance of gas purity, the impact of disruptions, and how Airgas can help you avoid running out of gas at the wrong time.







Industrial Gases Across all Parts of the Battery Ecosystem



Industrial gas use spans the entire battery life cycle, from mineral extraction and processing to component manufacturing, production, assembly and recycling.

No matter where you participate in this life cycle, it's important to understand the critical nature of maintaining an uninterrupted gas supply. A gas supply footprint needs to be extensive enough to be present at the local level with a robust infrastructure to accommodate the scaling needs of users.

Let's take a closer look at how gas continuity supports two key processes in the battery ecosystem:

- 1. Battery components
- 2. Battery production





How Industrial Gas Supports EV Battery Component Manufacturing

Battery component manufacturing relies on the strategic use of gases across nearly every step.

For instance, the calcination heat treatment for anodes which occurs when manufacturing battery components uses nitrogen to process materials under inert conditions, thereby preventing unwanted reactions like oxidation.

Similarly, cathode synthesis requires gases like oxygen, which are used for layered oxide cathode formation (for high nickel CAM). Here, nitrogen again plays an important role in olivine structure cathode (i.e. LFP) formation, as well as in the meticulous processes of material mixing, jet milling and spray drying. We also apply our knowledge of atomic layer deposition (ALD) to enhance battery performance by improving cyclability and durability to allow fast charging. ALD can realize all these by adding coatings only a few nanometers in thickness.

Airgas is pushing the boundaries of this field, continually working to extend battery life and reduce charging times in line with today's consumer expectations. Our commitment to research and development is evident in our close collaborations with our customers and our innovative technologies.









How Industrial Gas Supports EV Battery Cell Production

Cell manufacturing is a complex and intricate process where precision and safety are paramount.

Industrial gases are essential in ensuring battery systems are assembled efficiently and to the highest standards of quality.

Nitrogen is used in the mixing of active materials to prevent oxidation and maintain purity. Unless your nitrogen is generated by PSA (Pressure Swing Adsorption), our nitrogen contains low concentrations of moisture. This is essential for making high quality lithium-ion batteries. Water molecules and lithium salts in the electrolytes can react easily, leading to decomposition of electrolyte into unwanted chemicals like HF and PF₅. HF destroys the SEI (Solid Electrolyte Interface) layer and promotes the corrosion of cathode active material. Water molecules

will also make the graphite anode with embedded lithium partially delithiated, forming lithium hydroxide in the SEI layer.

Compared to dry air, using nitrogen eliminates the which can also accelerate battery aging.

Argon and carbon dioxide mixes are essential in ensuring battery systems are assembled efficiently and to the highest standards of quality. Welding and cutting operations are critical in assembly. Here, argon and carbon dioxide mixtures can protect the weld area from atmospheric gases, ensuring strong and reliable connections within the battery pack.



possibility of oxygen from air dissolving in the electrolyte,



Understanding the Importance of Industrial Gas Purity

Gas purity impacts every stage of the EV battery manufacturing process and is critical to ensuring that materials are processed in environments that are free from contaminants to help enhance each battery's performance, longevity and safety.

During synthesis and processing of battery components, gases with inert properties, like nitrogen, are essential to ensure chemical reactions occur as intended, without unwanted side reactions due to impurities. The coating of battery electrodes also involves high-purity nitrogen to prevent air exposure during slurry preparation and application. Once the slurry is on the foil, the same high-purity nitrogen facilitates the drying process by preventing the introduction of moisture.

Even minute amounts of contaminants can lead to corrosion, short circuits and other failures within the battery, compromising its safety and reliability. By using high-purity gases to create an inert environment inside the battery, manufacturers can enhance cyclability by facilitating ion flow and optimizing overall performance and longevity.









The Impact of Industrial Gas Disruption on Your Processes

Purity isn't the only factor EV battery manufacturers must consider. In today's fast-paced environment, any disruption in the supply of essential industrial gases can have a significant impact.

Unexpected gas runouts stall critical processes, such as the calcination of anodes or the formation of cathodes, leading to delays in the entire production schedule. They can also necessitate equipment recalibration, further extending downtime and affecting production quality.

To prevent disruptions, manufacturers need a gas provider that can supply industrial gases where and when they need them. This level of supply reliability is crucial for maintaining continuous production cycles and meeting the increasing demand for EV batteries.

Flexibility in supply is equally important, allowing manufacturers to quickly adapt to changes in production volume or process requirements. Whether scaling up operations to meet market demands or adjusting processes to incorporate new technologies, having a gas supply that can adjust to these changes is essential for seamless operations.





Why Reliable and Flexible Gas Supply is Critical

Airgas understands the continuity of gas supply is not just about keeping production moving; it's about maintaining the momentum of innovation and growth in the EV sector. Commitment to reliability means we must proactively manage supply chains to mitigate the risks of disruption.

Airgas bulk supply tanks can be equipped with a proprietary telemetry system. This electronic data acquisition and diagnostics system continuously monitors a facility's vital parameters.

If any of those parameters exceed normal specification, the system will automatically place a data call to the 24-hour National Scheduling Center at Airgas to diagnose the issue, ensuring a quick and efficient resolution.

We also provide a comprehensive maintenance program to ensure maximum uptime and reliability of the facility. And, our **Integrated Bulk Operations (IBO)** program enables safe transport of these bulk gases via more reliable and energy-efficient delivery routes. By ensuring a consistent and uninterrupted flow of industrial gases, we help our clients maintain their production schedules, uphold quality standards and stay ahead in the competitive EV market.







Choosing the Best Gas Supply Mode Optimizes Plant Operations

Selecting the right supply mode for industrial gases is a critical decision in the planning and operation of EV battery manufacturing. At Airgas, our diverse range of supply modes is designed to offer efficiency, cost-effectiveness and, most importantly, reliability.

We collaborate closely with our customers from the very beginning of their projects. This is key to understanding each operation's unique demands, allowing us to recommend the most suitable supply mode – whether it's gas cylinders, bulk, onsite generation or pipeline delivery.

Our approach takes into account factors such as a plant's capacity, location and specific production profile. By providing tailored solutions that best fit the operational scale and requirements of each facility, Airgas minimizes the risk of gas runout, thereby preventing potential production disruptions.

By strategically selecting the correct supply mode, our customers can maintain a steady focus on their core mission: driving innovation and producing the high-quality EV batteries that are powering the future.





Meet Your Sustainability Goals

Airgas is committed to helping our customers as they work to achieve their sustainability objectives, which is why we offer solutions aimed at reducing greenhouse gas (GHG) emissions associated with gas use.

Innovative gas technology like advanced cylinder valves, digital pressure monitoring systems for gas cylinders, and integrated bulk operations (IBO) logistics help reduce gas waste and promote more efficient gas transport and delivery.

Through ECO ORIGIN[™], we can provide certified, low-carbon bulk liquid argon, nitrogen and oxygen to help our customers reduce their emissions from gas usage in Scope 3. Our FLOXAL[™] on-site gas generation technology offers our clients direct access to an efficient and reliable supply of gases generated at their facilities. This minimizes the need for transport and helps reduce carbon emissions associated with gas transport.

Airgas also adheres to strict international standards, such as ISO 14067, to help our customers meet and exceed their sustainability goals by minimizing environmental impacts.









Innovative Gas Solutions for EV Battery Manufacturing

At Airgas, we're dedicated to helping our customers improve their manufacturing precision, innovate on processes and materials, and push the boundaries of what's achievable.

As a Platinum Member of <u>NAATBatt</u> International, an association for advanced battery technology, we're deeply committed to elevating the battery ecosystem, fostering innovation and supporting the development of advanced technologies to power the future. With our comprehensive range of gas solutions and our commitment to sustainability, we're poised to help you achieve your manufacturing goals and contribute to a cleaner, more sustainable future.



<u>Contact Airgas today</u> – together we can drive the future of electric vehicles forward.





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