

BOYD

3M Preferred
Converter
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Driving Innovation in
**Energy Storage
& Thermal Runaway
Prevention**



The demand for energy storage systems has surged with the rise of electric vehicles (EVs), the deployment of renewable energy sources, and the need for reliable grid applications. As the world shifts towards cleaner energy, efficiently storing and managing energy is crucial.

Effective thermal management is vital for these systems' performance and safety, especially with higher energy densities and more compact designs increasing the risk of thermal runaway—a dangerous event where battery cells overheat uncontrollably, leading to fires and explosions.

Boyd is a leading innovator in thermal management and thermal runaway protection, offering advanced materials and engineered solutions to enhance the safety and reliability of energy storage systems. Our expertise ensures optimal system performance while meeting stringent safety standards, effectively mitigating the risks associated with thermal runaway.



Thermal Runaway: Understanding the Challenge

Thermal runaway is a hazardous condition where an increase in temperature causes a self-sustaining reaction that leads to further temperature rises, potentially resulting in fires or explosions. This can be triggered by internal short circuits, overcharging, physical damage, or exposure to external heat. Once initiated, the rapid overheating of battery cells can quickly spread to adjacent cells and create a cascading effect. The compact design of modern battery packs, while beneficial for energy density, can also facilitate the rapid spread of thermal runaway if not properly managed.

In EVs, where battery packs are close to passengers, thermal runaway can have dire consequences. In grid storage applications, uncontrolled thermal events can disrupt power supply, damage equipment, and endanger maintenance personnel. To mitigate these risks, industry standards and regulations, such as those set by the International Electrotechnical Commission (IEC) and Underwriters Laboratories (UL), outline necessary precautions and testing procedures. Boyd's thermal management and thermal runaway protection solutions are designed to meet and exceed these standards, providing comprehensive solutions that ensure the safe and efficient operation of energy storage systems.

Boyd's Multi-Layered Approach to Thermal Runaway Protection

We take a comprehensive, multi-layered approach to thermal runaway protection, addressing potential risks at every level of the energy storage system—from individual cells to complete battery packs. This holistic strategy ensures robust, reliable, and safe energy storage solutions, tailored to meet the unique challenges of modern applications.

Compression Pads

Compression pads are critical to maintain battery cell integrity and performance. These pads are made from advanced materials that can withstand the repeated expansion and contraction cycles of the cells. They are designed to exert a consistent pressure on the cells, even as they swell and compress with temperature changes. Compression pads are typically made from elastomeric foams or other flexible, durable materials that can absorb and distribute pressure evenly. By maintaining consistent pressure, they prevent the deformation of cells that could lead to internal short circuits—a common cause of thermal runaway.

Flame Barriers

Flame barriers are essential to contain thermal events and prevent the spread of fire within a battery pack. These barriers are strategically placed between cells and around battery modules and packs to isolate any thermal incidents. Boyd utilizes various high-performance materials for flame barriers, including mica, ceramic fibers, and advanced composites like 3M™ Flame Barrier Paper FRB. These materials are chosen for their high thermal resistance and durability.

Seals & Gaskets

Proper sealing and gasketing are vital to protect battery modules from environmental contaminants and mechanical stresses. Seals and gaskets provide ingress protection, preventing water, dust, and other contaminants from entering the battery module. They also cushion against shock and vibration. Boyd offers a range of materials, including high-performance foams, elastomers, and pressure-sensitive adhesives (PSAs), each selected based on the specific environmental conditions facing batteries.

Liquid Cold Plates

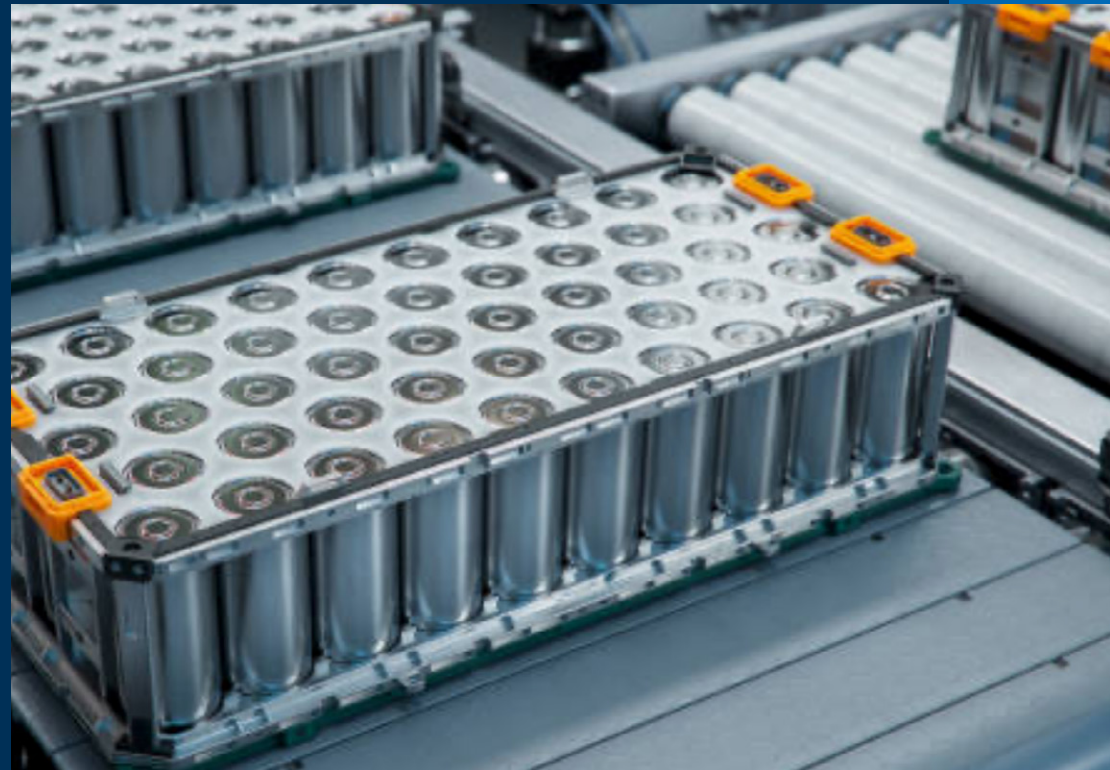
Liquid cold plates are integral to effective thermal management at the module level, providing efficient heat transfer to maintain optimal operating temperatures. Boyd's durable liquid cold plates are designed to integrate seamlessly within battery modules, using advanced fluid dynamics to circulate coolant through precisely engineered channels. Cold plates are made from high conductivity materials, such as aluminum or copper, and are often laminated with dielectric tapes for added electrical insulation that enhances the overall thermal stability and safety of the battery module.

Coolant Distribution Units and Chillers

Coolant distribution units and chillers are liquid cooling systems that deliver coolant to liquid cold plates to absorb system heat and safely discharge it. Boyd's liquid cooling system heritage includes zero field failures for reliable liquid performance. With redundancies and safety features, rely on Boyd's liquid cooling systems to efficiently and sustainably deliver coolant to cold plates for durable direct to heat source cooling.

Beyond Materials: Engineering for Prevention

In addition to providing advanced materials for thermal runaway protection, Boyd emphasizes the importance of engineering solutions that integrate seamlessly with Battery Management Systems (BMS) that leverage sophisticated software and algorithms. This holistic approach ensures early detection of potential liquid cooling issues and optimizes the overall design for safety and performance.



Battery Management Systems (BMS)

Battery Management Systems are crucial to monitor and manage the performance and safety of battery storage systems. Boyd integrates its liquid cooling system solutions with the BMS to enhance the overall protection and efficiency of the full battery system. We work closely with OEMs to ensure that their liquid cooling system solutions are compatible with existing Battery Management Systems. By integrating compression pads, flame barriers, and other thermal runaway protection materials, Boyd enhances the battery management system's ability to respond to potential events in early thermal monitoring. This synergy ensures that protective measures are activated promptly, mitigating the risk of thermal runaway or liquid cooling system malfunction.

Software & Algorithms

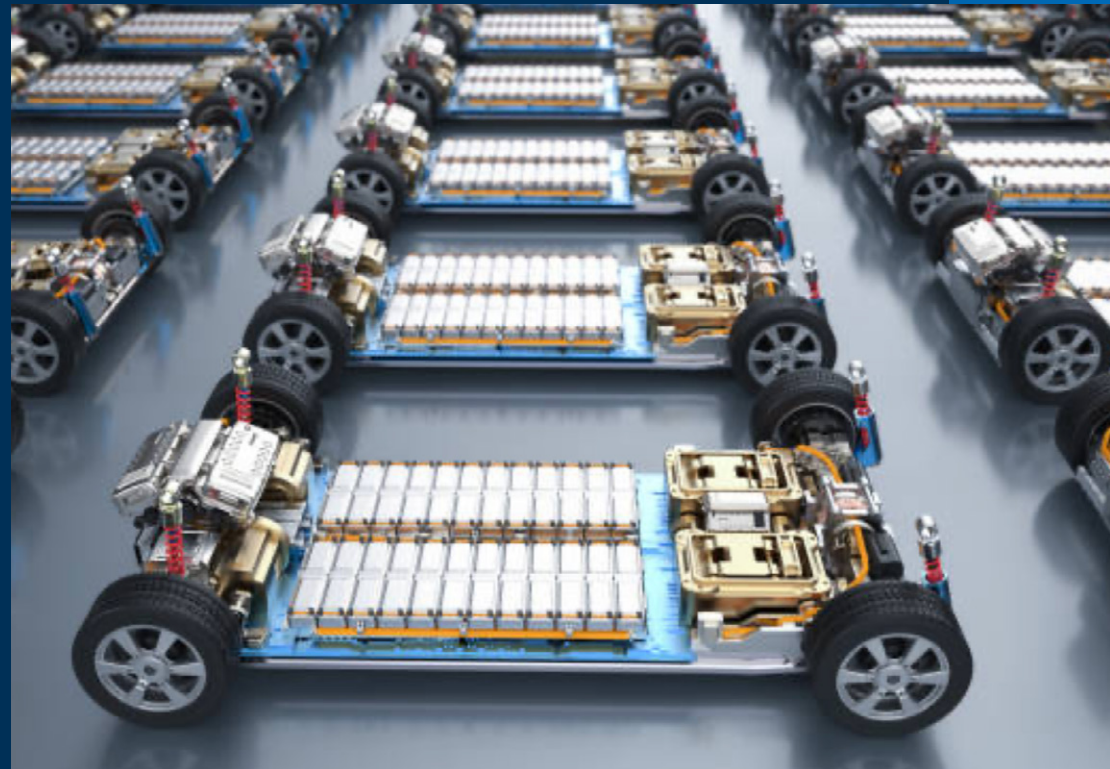
Sophisticated software and algorithms play a pivotal role in the prevention of thermal runaway conditions. Boyd collaborates with technology partners to incorporate advanced modeling and predictive analytics into their thermal runaway solutions. Algorithms and models analyze data during the design and prototyping phase to identify patterns indicative of thermal runaway. Boyd's rapid design support enables us to quickly iterate prototypes in response to thermal runaway simulations, aiding OEMs to safely and reliably refine their preventive thermal runaway solutions before new models go to market.

Design Optimization

Effective thermal management extends beyond adding protective or preventive materials. Boyd optimizes battery storage systems to enhance safety and performance by designing layouts that optimize air or liquid flow, minimizing the risk of hotspots and ensuring uniform temperature distribution. Our engineering team takes a holistic approach to physical layout, thermal dynamics, and mechanical stresses to ensure that all aspects of the battery thermal management system work together to prevent thermal runaway and enhance overall efficiency.

Boyd's Expertise & Solutions in Battery Technology

Boyd leverages its extensive expertise and innovative solutions to address the complex challenges of energy storage safety and efficiency. By combining advanced material science, custom engineering, and robust manufacturing capabilities, Boyd provides comprehensive solutions tailored to meet the specific needs of each application.



Material Science

Boyd utilizes a diverse range of materials, including high-performance thermal interface materials, flame barriers, electrically insulating materials, and more. This wide selection ensures that we deploy the best possible materials for any given application, rather than a one-size-fits-all solution. We continuously research and develop new materials to keep pace with the evolving needs of the energy storage industry.

Custom Engineering

Boyd's engineering capabilities ensure that each solution is precisely tailored to the specific requirements of the customer's system. Unlike off-the-shelf products, our solutions are custom engineered to meet the unique needs of each application. This includes designing components that fit perfectly within the existing system architecture and optimizing performance based on the specific operating conditions. We work closely with OEMs and system integrators to understand their challenges and requirements to exceed customer expectations.

Manufacturing

Boyd's manufacturing prowess ensures that high-quality solutions are delivered efficiently and at scale. We maintain stringent quality control processes across all manufacturing operations, which ensures every product meets the highest standards of performance and reliability. Our global manufacturing facilities are equipped to handle high-volume production, ensuring that even large-scale projects can be delivered on time and within budget.

The Future of Battery Storage Safety with Boyd

Boyd is leading the way in advancing battery storage technology and thermal runaway solutions, ensuring that its innovations remain at the forefront of safety and efficiency. Our commitment to innovation includes exploring new materials with superior thermal and electrical properties to improve thermal management and insulation. These advancements are critical for mitigating the risks of thermal runaway and enhancing overall system reliability.

The regulatory landscape for energy storage systems is continuously evolving, with new standards and requirements aimed at enhancing safety and performance. Boyd stays abreast of these developments, ensuring that its solutions comply with all relevant standards and helping customers navigate this complex landscape. Our partnerships focus on long-term success, working closely with customers to ensure that every aspect of their energy storage system is designed and implemented with safety in mind. This holistic approach encompasses material science, engineering, manufacturing, and ongoing support, ensuring that customers receive quality products and the expertise needed to achieve their goals.

Our commitment to manufacturing excellence, with over 40 ISO 9001 and nine IATF 16949 certified operations worldwide, guarantees that our products meet the highest quality standards. This global presence ensures efficient regional support and reinforces Boyd's role as a trusted partner in the energy storage industry. By improving thermal management and preventing thermal runaway, Boyd's solutions contribute to sustainability and reliability in renewable energy systems, ensuring efficient support for the grid and reliable power in remote locations.

