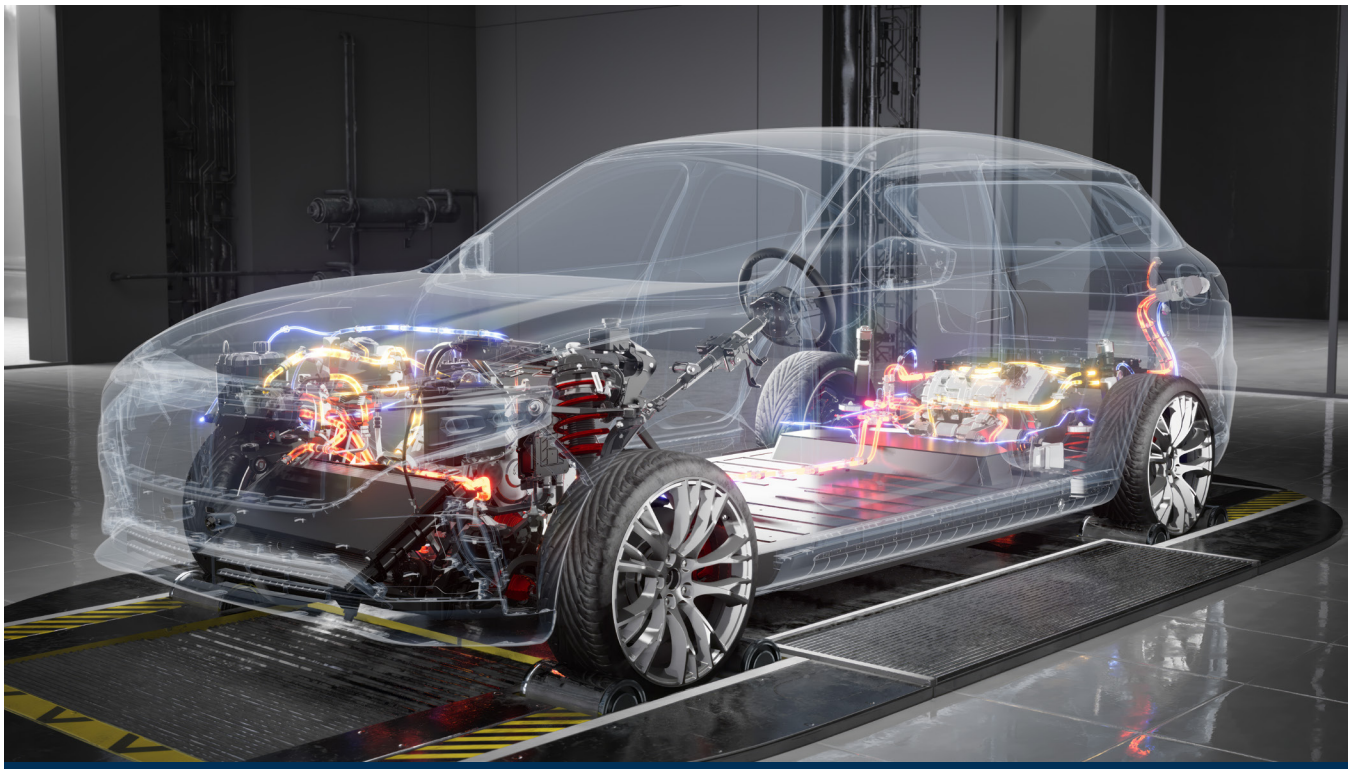
eMobility

BOYD

How Boyd's Customized Solutions Help EV Battery Manufacturers Prevent and Mitigate Thermal Runaway



Automotive OEMs need electric vehicle (EV) batteries that are safer, more reliable, higher performing, and longer lasting. But engineers are finding that many of the solutions they relied upon for internal combustion (IC) powertrains are inadequate to solve the challenges posed by batteries, including thermal runaway. The EV battery value chain needs engineered material innovators that address these challenges.

This white paper explores the evolving dynamics currently faced by EV battery pack designers and manufacturers. It then explains how Boyd, working with its industry partners, addresses manufacturers' needs. This paper is intended to aid EV battery engineers and business decision-makers in understanding and evaluating their technology partner capabilities.

EV MARKET SHARE TRENDS AND FORECASTS

The EV market has grown remarkably in recent years. According to an April 2023 report by the International Energy Agency (IEA), EVs' share of the overall automotive market grew from 4% in 2020 to 14% in 2022. That share is expected to reach 18% in 2023. The IEA expects EVs to have a 60% share of new vehicles sold in the U.S., the EU, and China by 2030.

The growth of EVs may be the most significant and disruptive trend in automotive production since the introduction of the assembly line over a century ago. However, many material engineering solutions that evolved incrementally with IC technology are increasingly inadequate to solve the new and unique challenges posed by EV battery pack design. To borrow a quote from Marshall Goldsmith, "What got you here won't get you there."

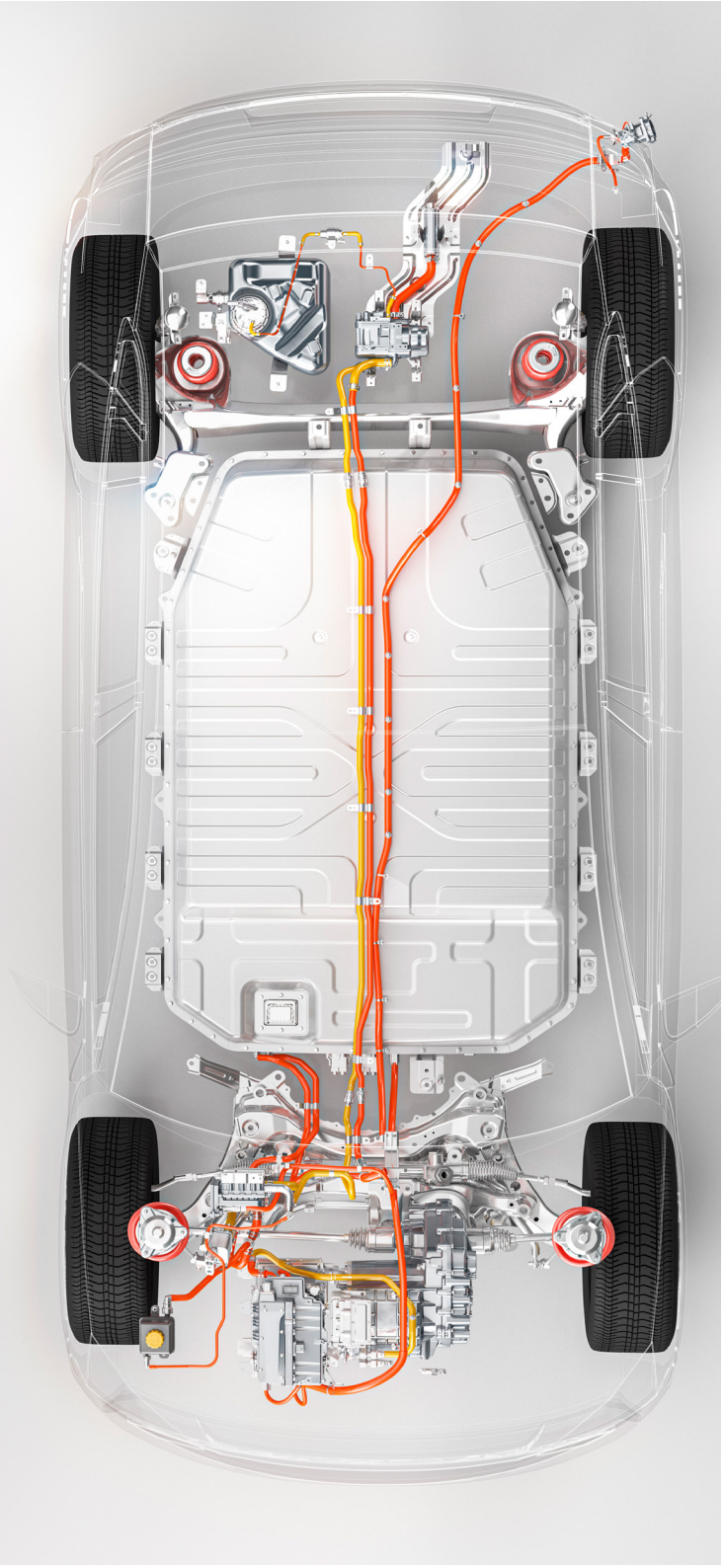
UNDERSTANDING THERMAL RUNAWAY

Thermal runaway prevention and mitigation are near the top of the list of these new and unique engineering challenges for many OEMs.

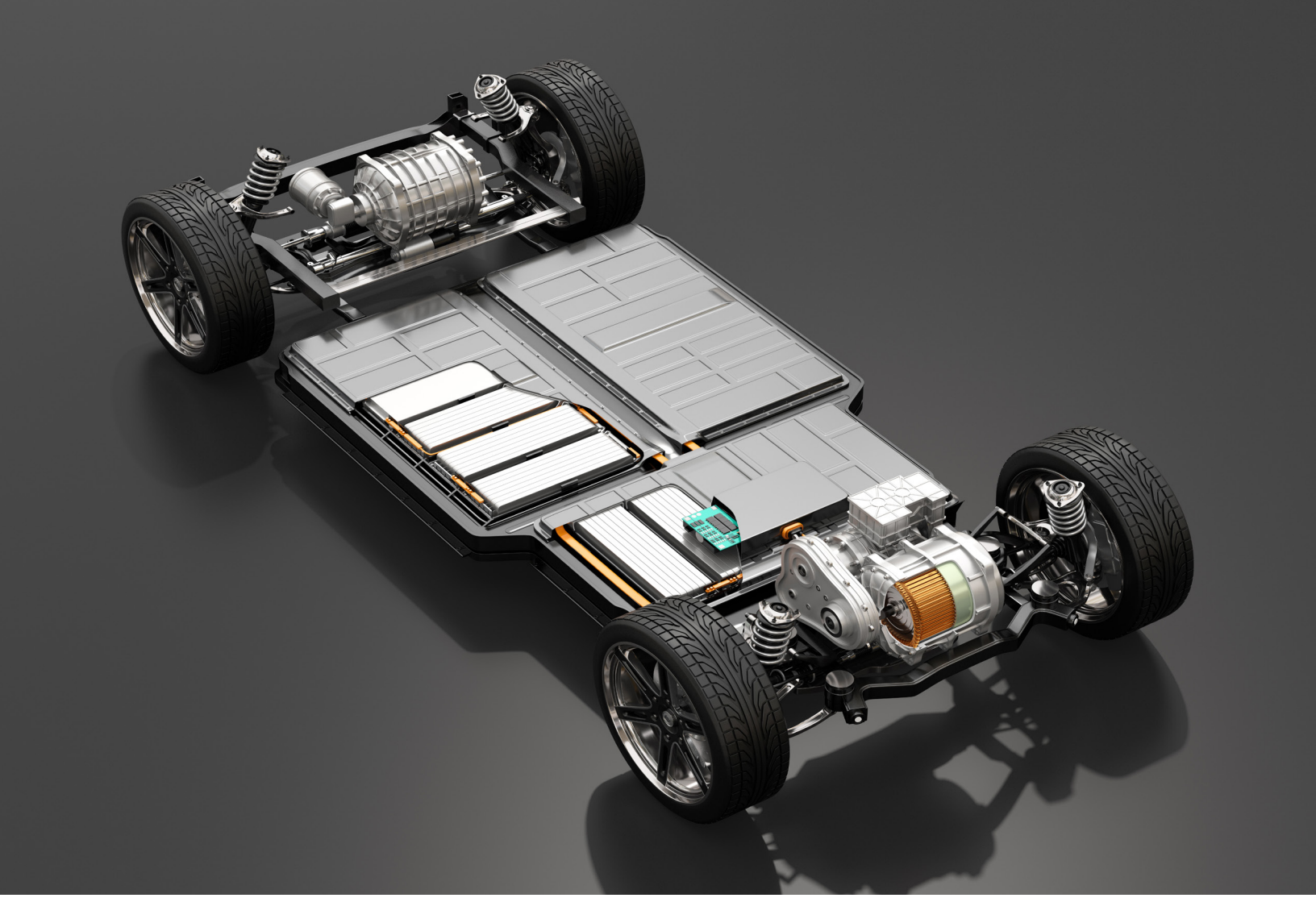
UL® defines thermal runaway as "one of the primary risks related to lithium-ion batteries …. in which the lithium-ion cell enters an uncontrollable, self-heating state."

In this uncontrollable state, heat is produced faster than it can dissipate. This may lead to violent venting of gas and smoke, high temperatures, and fire. It can also lead to a cascading effect throughout the pack in which heat from a compromised cell causes thermal runaway to initiate in neighboring cells.

Thermal runaway events can occur during pack and vehicle assembly, shipping, and end-use. And although the incidence of fire remains lower for EVs than for IC vehicles, the fires that do occur in EV batteries tend to be challenging to extinguish. Flammability thus remains a significant consumer safety and regulatory concern for electric vehicles.



Common thermal-runaway-prevention materials have included flame-retardant foams, papers, felt, and mica. However, as EV battery pack designers work to address the challenge posed by thermal runaway, many are discovering that there is no single, simple solution.



EV BATTERY PACK ENGINEERS ARE FACING A NEW SET OF DYNAMICS

As the EV market grows, engineers across the battery pack value chain are facing, and often struggling with, a new set of dynamics.

EV BATTERY PACK DESIGN IS INCREASINGLY VEHICLE-SPECIFIC AND SPACE-CONSTRAINED

Today's Li-ion battery-pack market is dominated by three basic designs: prismatic, cylindrical, and pouch-cell. However, most OEMs apply these designs in very specific ways to their own vehicles. More packs are being integrated into the car's structure and are much thinner than previous-generation packs. This has resulted in space constraints that leave limited volume for non-cell materials, including those that address thermal runaway.

ENGINEERED MATERIALS MUST FULFILL MULTIPLE REQUIREMENTS

Mainly due to the evolution of pack design as described above, OEMs are requiring materials that can fulfill multiple roles in a battery pack. These include flame retardancy, thermal interface, electrical insulation, compression, and shock absorption.

INDUSTRY-WIDE ENGINEERING STANDARDS FOR EV BATTERY PACKS DON'T YET EXIST

Some engineering best practices are emerging for EV battery packs. However, the automotive industry has yet to adopt broad standards governing testing, thermal management, dielectric strength, flame retardancy, and thickness of pack materials.

FEW INNOVATORS HAVE THE EXPERTISE AND AGILITY THE INDUSTRY NEEDS

In this fast-changing environment, material technologists are being pressed to develop solutions that deliver high performance, are thinner and lighter, and cost-effective. Solutions must also be increasingly customized to align with the unique needs of each OEM's battery designs. The EV battery pack value chain will rely on innovators that do the following:

- Understand their performance challenges and safety and reliability needs.
- Leverage industry partnerships to bring together multiple competencies.
- Use material-science expertise to optimize material selection and application.
- Excel at integrated manufacturing, at-scale, and with regionally replicated automotive quality management systems for reliable, repeatable, global service.
- Deliver high-quality customized solutions faster and more affordably.

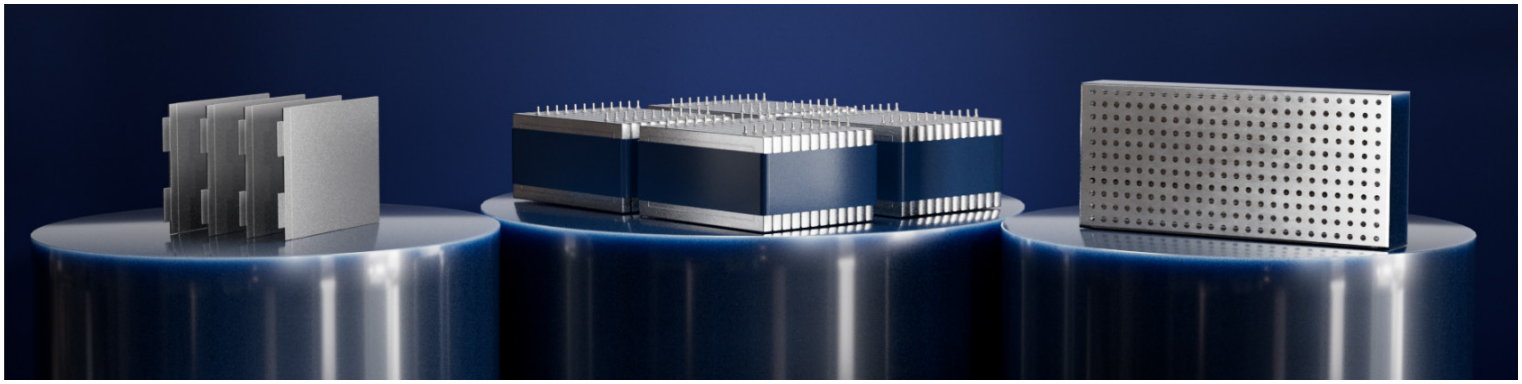
One partner that delivers these qualities — and more — is Boyd. Boyd is uniquely positioned to help the EV battery value chain address these challenges and develop packs that meet and anticipate the industry's evolving needs.

BOYD'S SOLUTIONS: CUSTOMIZED, INTEGRATED, INNOVATIVE

Boyd is an expert in thermal management with a 90-year track record of success across various industries. Through ten IATF 16949 automotive quality management system certified facilities across three continents, Boyd designs and manufactures multilayer engineered-material stack-ups that successfully address thermal-runaway prevention and mitigation challenges in modern, Li-ion EV battery packs.

BOYD OFFERS:

- Lightweight, high-performance sealing and cooling solutions that facilitate the design of larger batteries with greater power density.
- Solutions that ruggedize batteries to withstand harsh environmental and road conditions, helping extend battery life and range.
- Highly efficient, reliable, and sustainable liquid cooling systems that optimize power inverter and converter performance to maximize energy conversion efficiency, energy use, and power distribution to and from energy storage systems and EV batteries.
- Solutions that simplify customer assembly, design for manufacturing (DFM) throughput, and material optimization.
- Quick design cycles and fast prototyping to rapidly iterate designs, creating a competitive advantage in speed to market.
- Greater design flexibility with manufacturing capabilities that combine materials from various material science innovators, creating optimized multilayer material configurations.
- Streamlined, multifunctional solutions that seal, cool, and protect integrated system designs. These solutions reduce weight, create additional design space, and maximize energy creation, efficiency, and storage capacity.



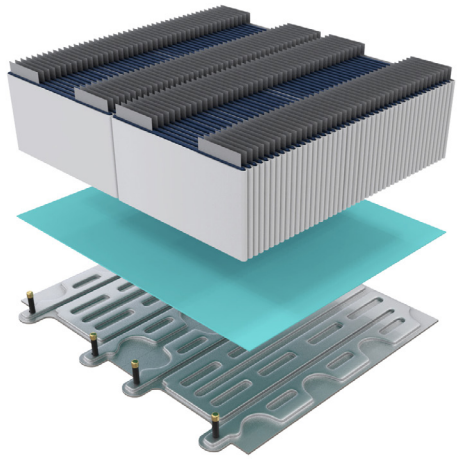
Importantly, Boyd leverages expertise gained by developing solutions for multiple industries, including automotive, aerospace and defense, electronics, semiconductors, medical, and more. Boyd brings a wide variety of problem-solving perspectives and applies innovation from these high performance and safety-oriented applications to anticipate EV industry needs.

BOYD'S PROCESS: MATERIAL SCIENCE AND A PROBLEM-SOLVING MINDSET

Boyd first works with each customer to gain a deep understanding of their challenges — their design constraints, production needs, and financial pressures.

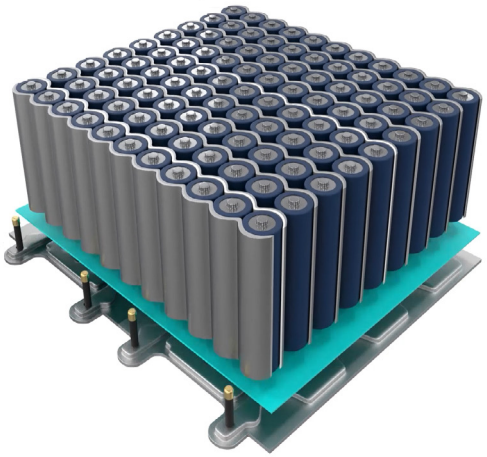
Boyd's thermal runaway solutions are wholistic, and address thermal, mechanical and electrical sources. Integrated solutions typically include a variety of materials that are recognized for their thermal management, damping, and insulating qualities.

- Ceramic papers
- Aerogels
- Mica
- Insulating foams
- Thermally and electrically insulating tapes and films
- Flame barrier papers



Boyd's product development team leverages the science behind these materials — their full range of physical properties and capabilities, how they might interact with other materials in a stack-up, and how those interactions might elevate their overall performance.

Boyd merges deep process knowledge with proprietary laboratory and production equipment to create integrated material solutions. Material stack-ups are kept to tight tolerances (down to +/-0.5mm) and are engineered to deliver multiple functionalities, such as flame retardance and dielectric strength. The resulting customized, cost-effective solution prevents or contains thermal runaway in the lowest profile possible without adding significant weight.



BOYD'S COLLABORATORS: INTEGRATING PRESSURE-SENSITIVE ADHESIVE TECHNOLOGY FROM AVERY DENNISON PERFORMANCE TAPES

Boyd frequently leverages industry collaborators that share its material-science expertise and problem-solving approach to provide effective, integrated solutions for EV battery packs. Avery Dennison Performance Tapes is one such collaborator.

Avery Dennison Performance Tapes brings decades of experience and expertise in pressure-sensitive adhesives, including a 50-year history of providing solutions to the automotive industry. Its portfolio includes multifunctional films, foams, and proprietary adhesives engineered for the rigors of EV battery packs.

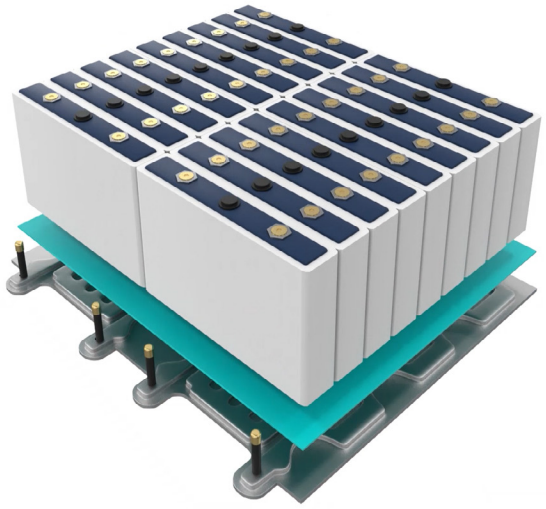
Avery Dennison Performance Tapes solutions:

- Enable multilayer functionality as a bonding solution for combining multiple materials in a stack-up.
- Bond engineered materials, including thermal barriers, to various parts of the pack, including cells, module walls, and pack enclosures.

• Encapsulate thermal barriers to protect delicate fibrous materials, provide dimensional stability, and simplify assembly.
• Offer various benefits compared to other bonding methods, including light weight, streamlined profiles, uniform adhesive coverage, high design flexibility, ease of application, and no cure time.

Avery Dennison Performance Tapes' featured solutions for EV battery packs include their Flame ToughTM and Volt ToughTM portfolios. These high-performance, pressure-sensitive adhesive tape products were developed specifically for bonding and encapsulation needs throughout EV battery pack assemblies.

• Flame ToughTM portfolio — A flame-retardant adhesives and films that enable composites and materials to meet UL® 94 V-0 and other flame requirements.
• Volt ToughTM portfolio — A portfolio of electrically insulative tapes offering varying degrees of dielectric breakdown strength (from 3kV to 10+kV), thin calipers to accommodate narrow battery pack designs, and optional flame-retardant qualities to meet UL® 94 V-0 and other requirements.



BOYD EV BATTERY PACK APPLICATIONS

Boyd's EV battery pack solutions encompass needs at the EV battery cell, module, and pack assembly levels.

THERMAL RUNAWAY PREVENTION AND MITIGATION

Boyd solutions for thermal runaway prevention and mitigation include materials that address thermal, electrical, or mechanical issues at any level of the battery pack. These include multifunctional battery component solutions designed for cell-to-cell applications that:

• Absorb impact, vibration, and movement that can damage cells and initiate thermal events.
• Dissipates heat.
• If needed, act as a flame barrier.

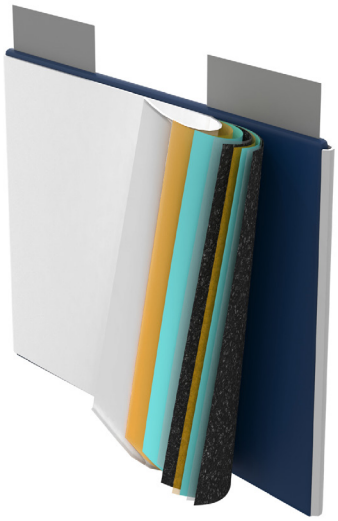
Multifunctional thermal runaway solutions may incorporate pressure-sensitive adhesive tape products, such as those from the Avery Dennison Performance Tapes' Flame ToughTM or Volt ToughTM portfolios.

CELL-TO-CELL BONDING

Boyd solutions include pressure-sensitive adhesives engineered to bond cells together. This includes flame retardant adhesives, such as Avery Dennison Performance Tapes Flame ToughTM product. Pressure-sensitive adhesives offer the added benefit of no cure time, helping improve assembly speed and productivity compared to liquid adhesive alternatives.

DIELECTRIC INSULATION

Boyd offers a wide range of custom-made electrically insulating materials to protect battery packs from electrical arcing. These include thin-film polymer-



based insulators with polycarbonate, polypropylene, or polyimide raw materials. Epoxy-based adhesives, various polyurethane adhesives, acrylic foam tapes, and structural tapes may be laminated to electrically insulating films to aid in the assembly process, adhere the insulators to the battery packs, and create a thermally conductive path through or around the electrical insulator.

These solutions can also incorporate flame-resistant adhesive tapes, such as those from the Avery Dennison Performance Tapes Volt ToughTM portfolio, adding functionality to the stack-up.

COMPRESSION PADS AND SEALS

Boyd's compression pads apply consistent pressure as cells swell and compress . This helps prevent what's known as "vampire drain," in which the battery slowly loses power during inactivity, negatively impacting battery efficiency.

Compression pads also aid in thermal-runaway prevention by helping to block or isolate thermal runaway, reducing heat-generating friction, and protecting cells against impact. Any of these incidents can damage them and cause spark or shorting issues.

FLAME BARRIER SOLUTIONS

Boyd specifies and custom configures flame barrier and thermal insulation materials. These materials can be used to wrap cells and prevent spark voltage between internal critical components that can lead to device shorting or fire.

Boyd also engineers and specifies thermal interface materials to enhance thermal runaway prevention solutions. These include gap fillers, thermal putties, thermal interface sheets, phase-change materials, and thermally conductive insulators.

Flame barrier materials may incorporate pressure-sensitive adhesive tape products, such as the Avery Dennison Performance Tapes Flame ToughTM adhesive.

BATTERY HOUSING SEALS AND PORT GASKETS

Boyd's specialty materials and smart gasket design waterproof and seal EV battery housings to protect sensitive battery components from contamination and road debris. They also help eliminate noise, vibration, and harshness (NVH) challenges to optimize reliability, performance, and the driver experience.

These gasket and seal materials are often combined with pressure-sensitive adhesives, including those from the Avery Dennison Performance Tapes portfolio. Their long-term durability helps the battery pack operate optimally over the vehicle's life, preventing thermal runaway.

All materials are engineered for ease of assembly, design-for-manufacturing (DFM) throughput, and material optimization.

THE BOYD ADVANTAGE

Boyd is the trusted global innovator of sustainable solutions that make our customers' products better, safer, faster, and more reliable. Our innovative engineered materials and thermal solutions advance our customers' technology to maximize performance in 5G infrastructure and the world's most advanced data centers; enhance reliability and extend range for electric and autonomous vehicles; advance the accuracy of cutting-edge personal healthcare and diagnostic systems; enable performance-critical aircraft and defense technologies; and accelerate innovation in next-generation electronics and human-machine-interface. Core to Boyd's global manufacturing is a deep commitment to protect the environment with sustainable, scalable, lean, strategically located regional operations that reduce waste and minimize carbon footprint. We empower our employees, develop their potential, and inspire them to do the right things with integrity and accountability to champion our customers' success.

To receive more information, please visit www.boydcorp.com.

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Ready to start your next project?

Contact Boyd today to see how we can help you improve thermal runaway protection in EV batteries.

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