

Battery Energy Storage System
Thermal Runaway Propagation Mitigation

Superwool® EST™ Products





THERMAL CERAMICS

High-performance thermal management applications world-wide

Advanced materials for Thermal Runaway Mitigation

Thermal Ceramics manufactures a range of Superwool® EST (Energy Storage Technology) designed to prevent the propagation of thermal runaway in electric vehicle and energy storage applications.

We collaborate with our customers to integrate EST products for thermal runaway protection in cell-cell, module-module, and pack protection systems. Concerns for space and weight can be mitigated with EST materials including:

- Papers
- Shapes
- Bulk powder

Morgan's global manufacturing footprint allows us to work directly with your team whether they are in Asia, Europe, or the Americas. Our many years of manufacturing and direct supply to the automotive industry give us the background needed to bring ideas and material solutions into the reality of volume production.

Application engineering

Extensive range of high temperature insulation products used to thermally manage battery systems.

- Working with customers to understand application and define performance parameters
- Research to find the best material for your system
- Development of prototypes and pilot production

Integrated approach of
consultation, design,
material selection,
development & production

Superwool EST Products Applications Overview



EST Compression Papers
Pouch & Prismatic Cell to Cell Protection



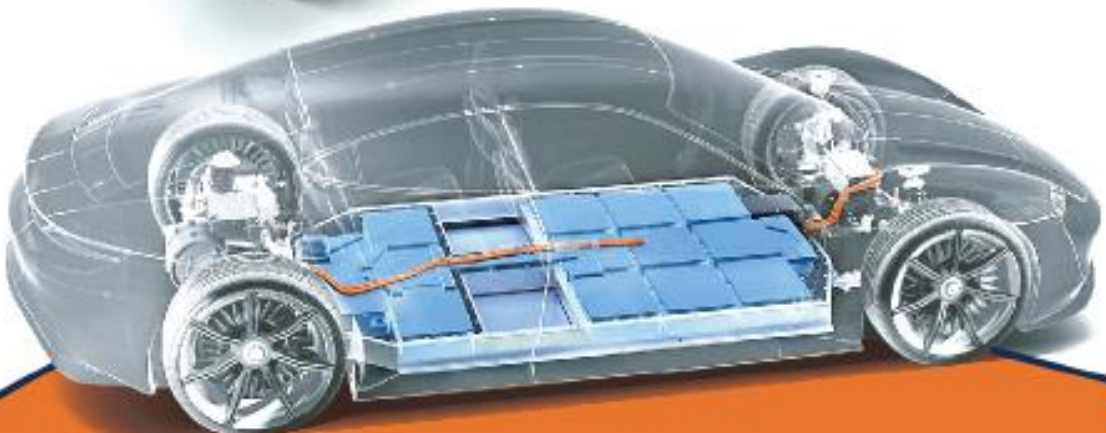
EST M Paper, EST G Paper,
EST E Paper with IC100 Coating
EST Guard

Module to Module Protection

EST Block, EST Guard, EST E Paper
Cylindrical Cell to Cell Protection



EST G Paper, EST M Paper,
EST P Paper, EST D Paper,
Pack level protection



EST™ Products for Battery Safety and Energy Storage

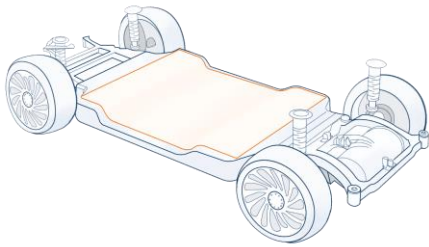
Our EST™ Product Line has been specifically designed for lithium ion systems to prevent or delay thermal runaway propagation. It comprises of our patented Superwool low biopersistent fibres with enhanced insulative, endothermic, and intumescent materials designed for space and weight constraints without loss of safety and performance, to optimize through one or many separate mechanisms:

- **Thermal Energy Absorption:** Energy absorption to reduce the amount of thermal energy.
- **Hot Gas Evacuation:** Decomposition products continue to propel hot gases out of the housing after the event, thereby reducing energy available for heating.
- **Thermal Resistance:** Slows the rate of thermal transmission from the event area. This allows time for heat to conduct to entire apparatus, and gives time for heat to be evacuated by decomposition gases (above).

Benefits

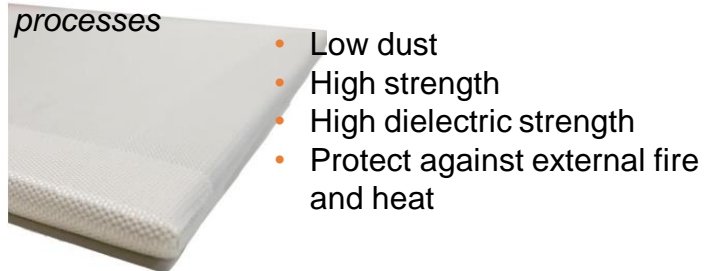
- Meets UL94 V-0 requirements
- Light weight
- Low thermal conductivity
- Excellent finished surfaces
- Adhesive capable design
- Dust suppressant coating
- Easily cut to shape or customizable
- High classification temperature ranging 1100-1300°C
- No asbestos and RoHS compliant
- Not classified as any carcinogen as per the NOTAQ Standard under REACH 97/69 EC

Pack level Protection



EST G Paper

Fibreglass encapsulated Superwool fibres paper with specialty adhesive and sealing processes



- Low dust
- High strength
- High dielectric strength
- Protect against external fire and heat

EST P Paper

Composite paper product with Superwool bulk fibres and flame retardant heat sealing film with specialty adhesive and sealing processes



- Water Resistant
- High strength
- Low dust
- Protect against external fire and heat

EST D Paper

Paper with Superwool® bulk fibres and organic binders, surface coated on one side for dust suppression



- Low dust
- Easily cut to shape

EST M Paper

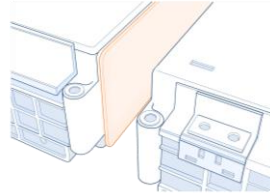
Mica laminated paper with Superwool fibres, mica facing allowing higher dielectric strength values



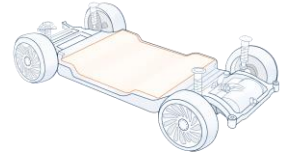
- Water-resistant
- High dielectric strength

Applications

Module to Module



Pack level



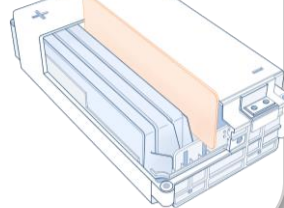
EST E Paper

Flexible endothermic paper with Superwool fibres designed to undergo a phase change to remove heat

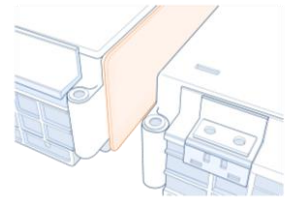


- High endothermic loading

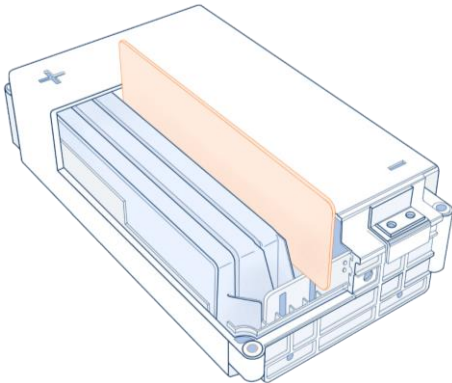
Cell to Cell Pouch & Prismatic



Module to Module



Cell to Cell Pouch & Prismatic



EST Compression Papers

Thermal Ceramic's low biopersistent Superwool fibers combined with a unique binder system and fillers to control the overall compression forces within targeted ranges.

- Designed to displace foam inserts typically with non-flammable UL94 V-0 rated substitute
- Accommodate the cyclical expansion pouch and prismatic cells experience during normal operation



Pouch EST C30 Paper

Prismatic EST C310 Paper

EST Block

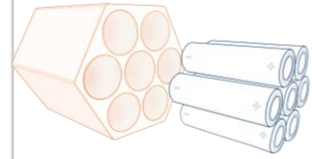
Rigid, machined housing with Superwool® fibres designed to undergo a phase change to remove heat from thermal runaway event



- High endothermic loading
- Allows for ultra-thin spacing
- Safe to be machined
- Can be customized

Application

Cell to Cell
Cylindrical



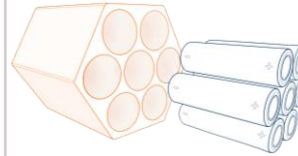
EST Guard

Rigid, ceramic phase change material in customizable shape

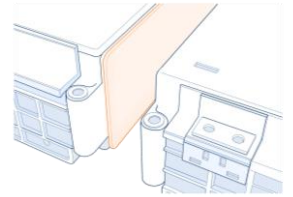


- High MOR strength
- High endothermic loading
- Hydrophobic
- No post-forming machining required
- Dust free

Cell to Cell
Cylindrical



Module to Module



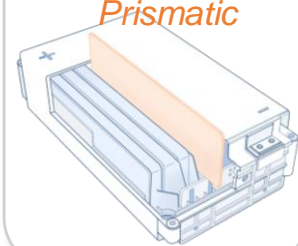
EST E Paper

Flexible paper with Superwool® fibres designed to undergo a phase change to remove heat

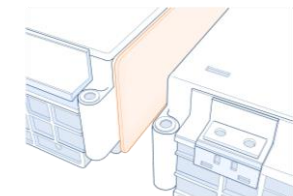


- High endothermic loading
- Adhesive capable design

Cell to Cell
Pouch &
Prismatic

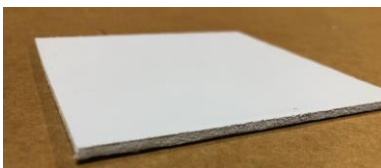


Module to Module



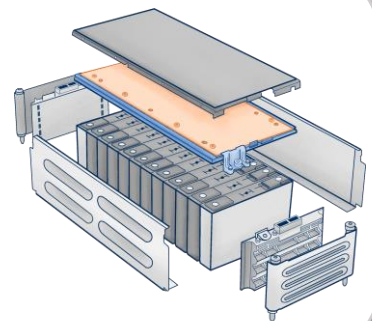
EST IC100 Coating

Water-based thin-film intumescent fire protection coating, acts as a char barrier between heat source and cold face



- Enhances insulative value of ceramic fiber
- Good dielectric strength

Module or
Pack Lids



coated on EST papers for additional protection

Superwool® Papers

Low Biopersistent insulating fibre solutions

Superwool fibre family of products are classified as Alkaline Earth Silicate (AES) and fully exonerated from any carcinogen classification in the European Union under the Provisions of Directive 97/69/EC.

Superwool Paper is a unique family of paper products manufactured using our patented Superwool low biopersistent fibre in the non-woven matrix. Special organic binders and fillers are used for giving them strength and distinct physical properties suitable as material in thermal runaway propagation solution. **Ceramic fiber leaves a thermally resistant structure during a thermal event.**

Our QS 9000/ISO 9002 certified quality, lightweight papers feature equal or superior performance with reduced costs, low thermal conductivity, durability, compressibility and flexibility.

Features

- RoHS and ELV compliant
- Meets UL94 V-0 requirements
- Flexible utility paper with a continuous use limit up to 1150°C
- Low thermal conductivity
- Thermal shock resistant
- Light weight
- Easy to die-cut
- Thickness consistency, available 1 - 6mm
- Resistance to chemical attacks*
- Unaffected by incidental spills of oil or water**

*exceptions include hydrofluoric acid, phosphoric acid and strong alkalis)

** Thermal and physical properties are restored after drying.

Typical Properties	Superwool Plus Paper
Classification temperature ¹	1200 °C
Continuous Use temperature	1000 °C
Density ¹	180 - 250 kg/m ³
Tensile Strength ¹	0.45 Mpa
Loss of Ignition	< 10%
Linear Shrinkage ¹	< 4%
Thermal Conductivity ²	
@ 600°C	0.11 W/m.K
@ 800°C	0.15 W/m.K
@ 1000°C	0.21 W/m.K

¹ Tested to EN 1094-1

² Tested to ASTM C201

Superwool®
Insulating fibre

has been a mark of quality in high temperature, low biopersistent fibre insulation, since the 1990s.

THERMAL CERAMICS

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