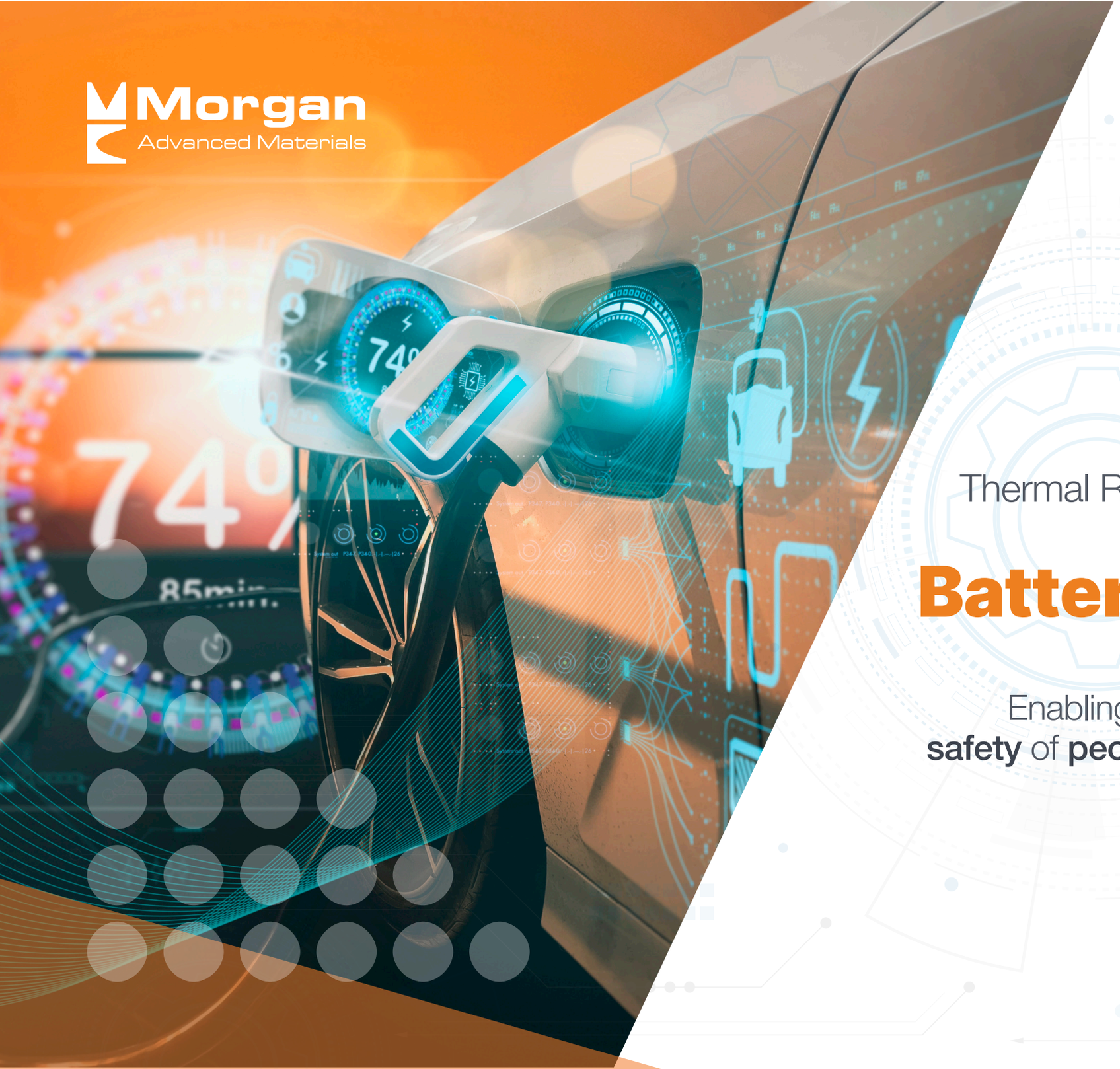
Morgan
Advanced Materials

THERMAL CERAMICS



Thermal Runaway Mitigation EST™ Materials for **Battery Safety**

Enabling **sustainability** and **safety** of **people** and **processes**

> **Automotive**

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Thermal Runaway Mitigation

We manufacture a range of Superwool® EST™ (Energy Storage Technology) products and systems, designed to prevent or delay 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.

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Thermal Ceramics

We innovate to meet the challenges of a changing world

Safe and Reliable Products

Our products and systems protect lives and processes 24 hours a day and 365 days of each year.

A Truly Global Footprint

We have operations on 5 Continents and in 30 countries to efficiently serve our Customers.

Commitment to Innovation

For you, for us, for our people and our planet, our commitment to innovation is paramount in all we do.

Trusted Engineering Services

Our global resources and dynamic engineering services efficiently support our Customers application demands.

The Thermal Ceramics business of Morgan Advanced Materials makes advanced ceramic products and systems for thermal insulation in high temperature environments. We design products and systems for equipment used in challenging environments and applications, prioritising safety for individuals.

Our solutions help customers, especially those operating energy intensive processes, to reduce energy consumption, emissions and operating costs.

What we do in Transportation industries

Across our Morgan businesses, we are Tier 2 and 3 suppliers of ceramics, components and systems to the Automotive market.

Our Thermal Ceramics business manufactures a range of materials and components to thermally insulate heat shields and exhaust after-treatment components, advanced fibre technology to prevent thermal runaway propagation in battery systems, and engineered fibres significantly increase brake friction pad stability improving fade and recovery characteristics.

We are at the forefront of technology, partnering with manufacturers to improve vehicle safety, performance, energy efficiency and comfort.

Harnessing our world-class design expertise and specialist manufacturing capabilities, we work in partnership to develop competitive tailored solutions to meet the increasingly challenging and changing demands of the automotive market.

Morgan provides insulation solutions across the transportation sector - rail, aerospace, marine and other road vehicles, including heavy goods vehicles, buses, motorcycles and scooters.

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Products Overview

Our EST™ product line has been specifically designed for battery systems to prevent or delay thermal runaway propagation.

It comprises of our patented Superwool® low biopersistent fibres with enhanced insulation and endothermic materials designed for space and weight constraints without loss of safety and performance, to optimise through one or many separate mechanisms:

THERMAL RUNAWAY PREVENTION

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).

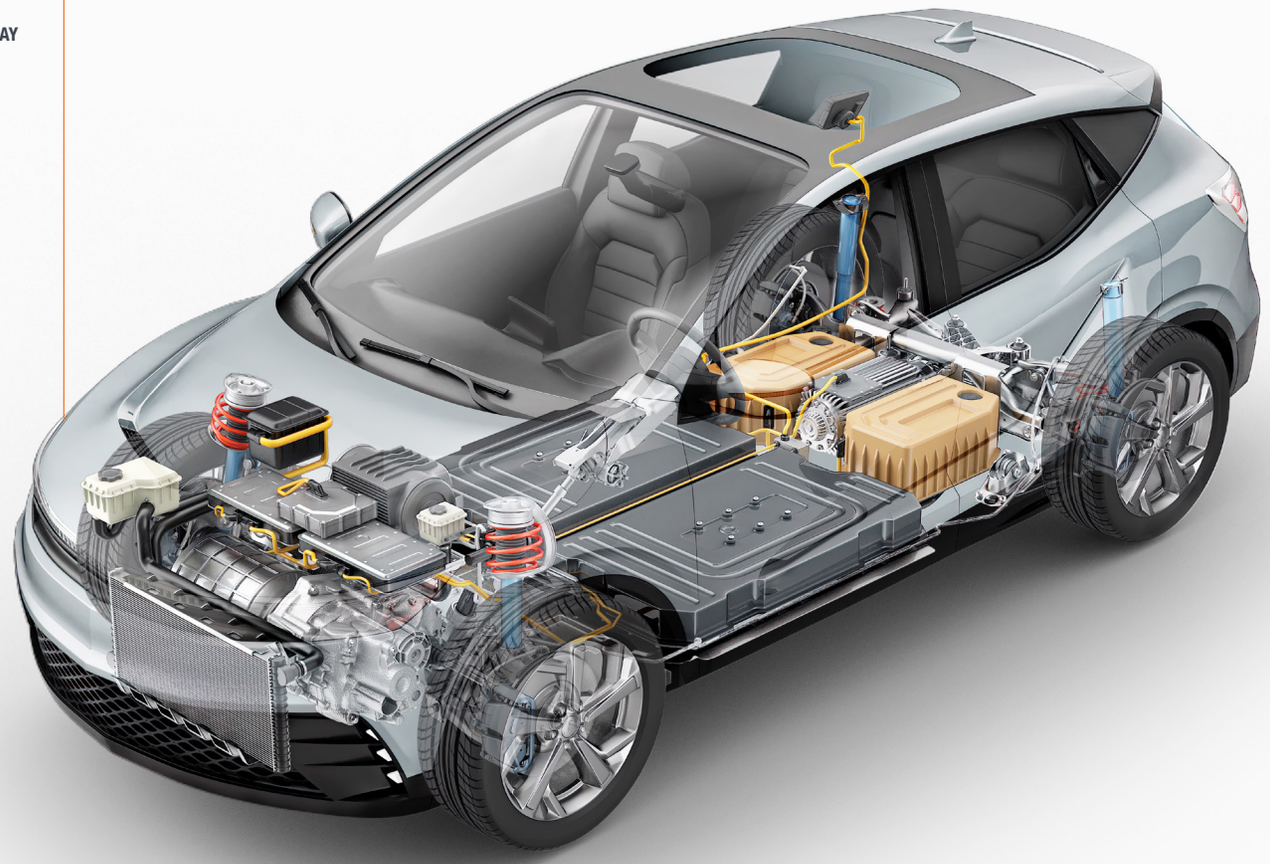
Benefits

- High classification temperature ranging 1100-1300°C
- Meets UL94 V-0 requirements
- Light weight
- Low thermal conductivity
- Excellent finished surfaces
- Adhesive capable design
- Dust suppressant coating
- Easily cut to shape or customisable
- No asbestos and RoHS compliant
- Not classified as any carcinogen as per the NOTE Q Standard under EC/1272/2008

EST 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 Regulation (EC) No. 1272/2008.



EST™ Papers for battery safety

Our EST Paper portfolio is uniquely developed with Superwool® fibres and specially processed with unique capabilities for Battery applications in Electric Vehicles.

Superwool Paper is a unique family of paper products manufactured using our patented Superwool low biopersistent fibre in the non-woven matrix.

Organic binders and fillers provide strength and distinct physical properties suitable as material in thermal runaway propagation solution. Ceramic fibre leaves a thermally resistant structure during a thermal event.

Benefits

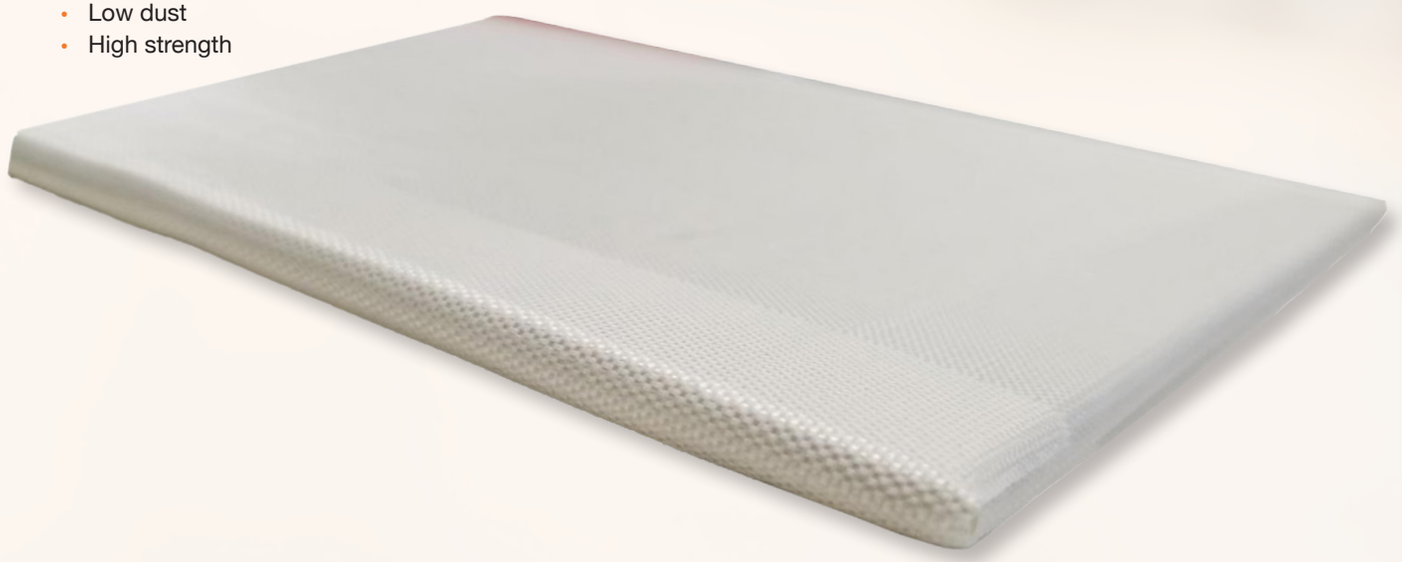
- Meets UL94 V-0 requirements
- Light weight
- High classification temperature ranging 1100-1300°C
- Low thermal conductivity
- Excellent finished surfaces
- Adhesive capable design
- Dust suppressant coating

EST G Paper

Pack Level Protection

Fibreglass encapsulated Superwool fibres paper with specialty adhesive and sealing processes.

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

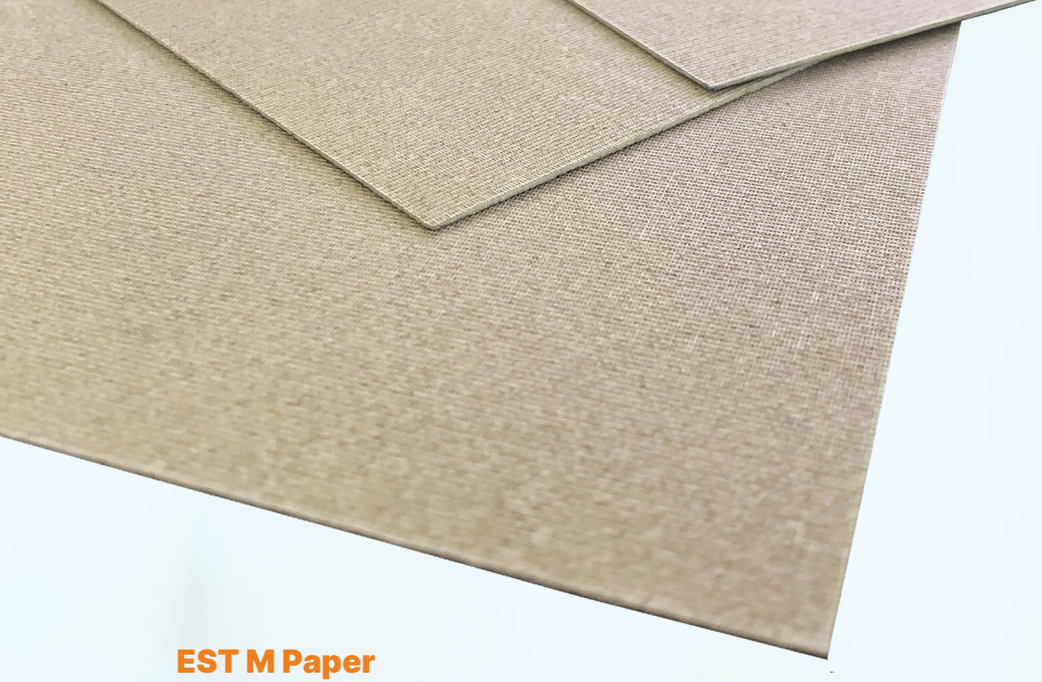


EST E Paper

Cell to Cell
Module to Module

Flexible Superwool fibre paper matrix with endothermic fillers that undergo phase change to remove heat.

- High endothermic loading
- Easily cut to shape



EST M Paper

Module to Module | Pack Level Protection

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

- Water-resistant
- High dielectric strength

EST Compression Papers

Cell to Cell

Thermal Ceramics low biopersistent Superwool fibers combined with a unique binder system and fillers to control the overall compression forces within targeted ranges at the beginning of life and end of life conditions.

- 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

Partnering with us

We are the partner of choice for the automotive sector, both in the conventionally powered and electric vehicles market. By partnering with Morgan, customers are able to push the boundaries of performance without compromising safety, heat or weight management.

Our custom solutions are developed using our patented Superwool® Fibre and WDS® Microporous materials. These technologies help vehicle designers achieve optimal thermal management and passive fire protection, throughout the engine, exhaust, control and battery systems.

Our innovations support effective emission control and enable customers to develop safer, more sustainable and better performing conventional, electric and hydrogen powered vehicles

Benefits of partnering with Morgan

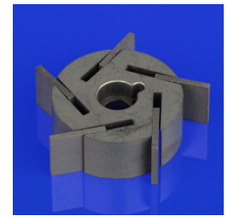
Harnessing our world-class design expertise and specialist manufacturing capabilities, we work in partnership with some of the world's largest Tier 2 and 3 automotive suppliers, developing competitive tailored solutions to meet the increasingly challenging demands of the sector. We are at the forefront of technology helping manufacturers improve vehicle safety, performance, energy efficiency and comfort.

- **Research and development**
  A dedicated team focused on innovating within the automotive industry, developing superior materials which excel in real-world applications.
- **Global manufacturing**
  Operations on five continents, we collaborate with customers and deliver solutions in region to support the 'just in time' manufacturing model.
- **Supporting the reduction of carbon dioxide**
  Innovative solutions, designed and engineered to drive a reduction in emissions.

Our expanding automotive business

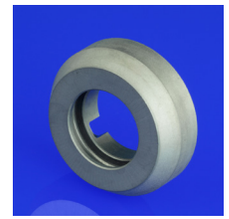
Products used in vehicles

Morgan's ultrasonic sensors are used in personnel detection systems, enabling automotive manufactures to ensure that the airbags are deployed in the safest possible manner according to the passenger's position and meet stringent safety requirements.



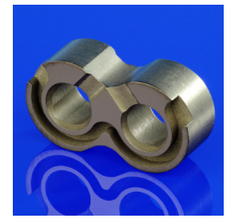
Hybrid vehicle cooling pumps

The properties of our ceramic materials is enabling the pump technology needed in electric and hybrid vehicles to circulate aggressive coolant through the battery system batteries, whilst also providing weight saving benefits.



Carbon bearings, vanes and rotors

Our Performance Carbon business also produces carbon / graphite vanes and rotors offering outstanding thermal and chemical resistance properties along with superb wear resistance. Applications include; Fuel Pumps, Water Pumps (Cooling / Heating), EGR Valves and Electric Vacuum Pumps.



Together, we are working to reduce our environmental impact...

...together, we are working to deliver robust environmental, social & governance (ESG) practices, and together, we have defined **five** environmental, social, and governance (ESG) improvement objectives and targets to improve our performance as a Group...

CO_2 REDUCTION

Reduce our environmental impact

1 Our aspiration is to be a CO_2 net zero business by 2050.
Our 2030 target is to reduce our scope 1 and scope 2 CO_2 emissions by 50% (from a 2015 baseline).
We will start to measure scope 3 emissions from 2023 onwards, with coverage increasing over time.

2 Our aspiration is to use water sustainably across our business.
Our 2030 target is to reduce our overall water usage by 30% and
reduce our water usage in high stress areas by 30% (from a 2015 baseline).

SAFETY PERFORMANCE

Improve our safety performance

3 Our aspiration is to create an environment and culture with zero harm to our employees.
Our 2030 target is a lost time accident rate below 0.1 (lost time accidents per 100,000 hours worked).

DIVERSITY AND INCLUSION

Improve the diversity and inclusion of our business

4 Our aspiration is that our employee demographics reflect the communities that we operate in.
Our 2030 target is for 40% female representation across our leadership population of our organisation.

5 Our aspiration is a welcoming and inclusive environment where our employees can grow and thrive.
Our 2030 target is to attain a top quartile employee engagement score.

For more information please visit: www.morganthermalceramics.com/sustainability-responsibility

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THERMAL CERAMICS

Morgan Advanced Materials

Significant trends shape our modern world, accelerating the demand for new and more sustainable advanced materials.

At Morgan Advanced Materials, we use advanced carbon and ceramics materials to support the move to a more sustainable world. Our people are driven to solve complex customer problems: from managing heat and enabling greener technologies, to supporting improved medical diagnostics and protecting life.

Our Purpose

Our purpose is 'to use advanced materials to make the world more sustainable, and to improve the quality of life'. This purpose is underpinned by our safe, ethical and inclusive culture, embraced by our 7,800 employees spanning over 25 countries. Working across many industries and in a number of markets, we deliver the materials science and technologies the world needs now.

Our Strategy

We are a global advanced manufacturing organisation with leading capabilities in three areas: materials science, application engineering and customer focus.

Our Business Model

We operate as two global divisions and five global business units. We empower our global business unit teams, giving them considerable autonomy and enabling them to act quickly and support their customer needs. Our broad manufacturing footprint enables us to supply customers locally from a short supply chain.

www.morganthermalceramics.com
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