

Advanced thermal
management solutions for
Transportation

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

> Automotive

Transportation

Providing innovative, engineered thermal management and passive fire protection solutions to reduce emissions and enable customers to develop safer, more sustainable and better performing conventionally-powered, electric and hydrogen-powered vehicles.

We are the partner of choice for the automotive sector, both in the conventionally powered and electric vehicles market. Working with us, 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® and EST™ Fibres 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.

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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 engineer products and systems for equipment in demanding applications and for the safety of people.

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 1, 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 lithium-ion 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 to create more fuel-efficient, safer vehicles.

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.

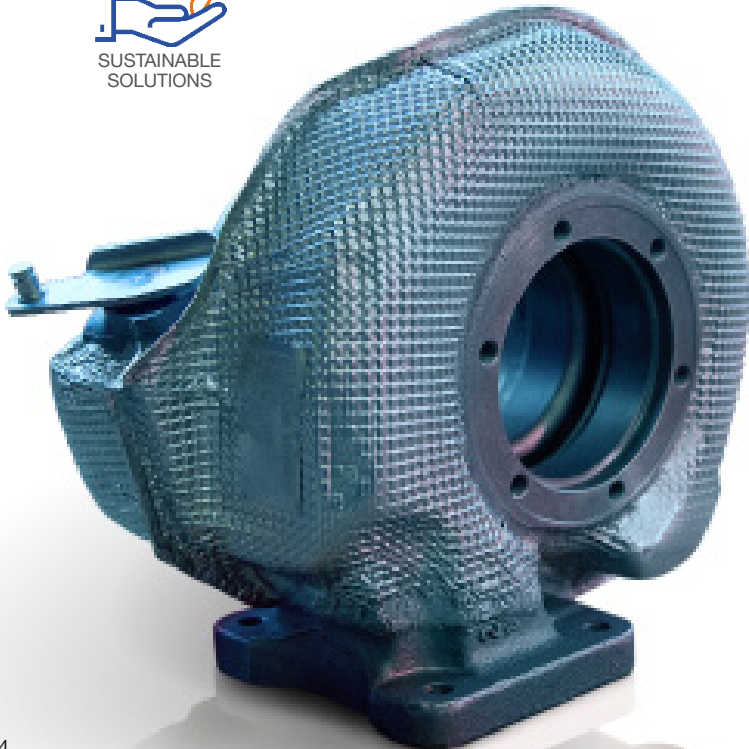
Morgan provides insulation solutions across the Transportation sector - rail, aerospace, marine and other road vehicles, including heavy goods vehicles, buses, motorcycles and scooters.

Heat Shields

Morgan's thermal acoustic heat shields are multi-layered products designed to provide optimum performance in high temperature environments.



Engine compartments are becoming more compact requiring more efficient thermal management solutions that dissipate heat. Morgan heat shields combine thermal performance with superior material design providing high temperature resistance in these very demanding heat shield applications.



Our global advantages

- Vertically integrated within the supply chain to provide our proprietary material solutions from our global manufacturing footprint
- Engineered and designed through partnership with automotive industry leaders to ensure demanding challenges achieved
- Global manufacturing locations strategically located in Americas, Asia and Europe, research and engineering technology teams and focused customer services



Key advantages of our heat shields

- **Lightweight and space critical** engineered solutions
- **Superior thermal and acoustical** performance
- **Safety Edges** - all automotive heat shields are designed with a safe edge feature
- **Complete assembly development** - automotive heat shields from Morgan are engineered, designed, developed and delivered to the customer's site for installation or completely assembled to the application
- **Quick change** tooling, durable crimping and/or welding assembly are all critical in automotive heat shield manufacture and delivery



Heat shield technologies and capabilities

Direct heat shields

- Morgan Shell Technology is a single steel shell custom engineered designed to fit directly onto the hot part.
- Thin foil steel combined with unique surface dimpling allows the material to be formed into complex shapes without compromising the integral structure of the heat shield itself.
- Can be designed to be removeable or fixed for the lifetime of the application.
- Excellent vibration resistance.

Integrated solutions

- Integrated Solutions are custom fit heat shields that are supplied assembled around the customers part.
- Multiple options for fixation to the inner part, single or double crimping combined with seam / spot welding provides a low-cost assembly solution with excellent vibration resistance.

3-layer heat shields

- 3-Layer Sandwich Technology provide insulation and acoustic absorption in areas of sensitive parts.

Flexible jacket insulation

- Systems manufactured with fabric inner and outer layer, can be used in combination with any insulation layer.
- A wide range of fabric materials depending on thermal requirement.
- Suitable for smaller volumes and does not require expensive tooling.
- Easy installation and removal.
- Short manufacturing lead time for prototypes and production.

Services

- Rapid prototype development reducing off tool lead times by optimising in-house process and tool design.
- Mounting tools for installation at the customer site including manufacturing and design with customer target TAKT times in mind.
- Thermal simulation.

Insulation materials

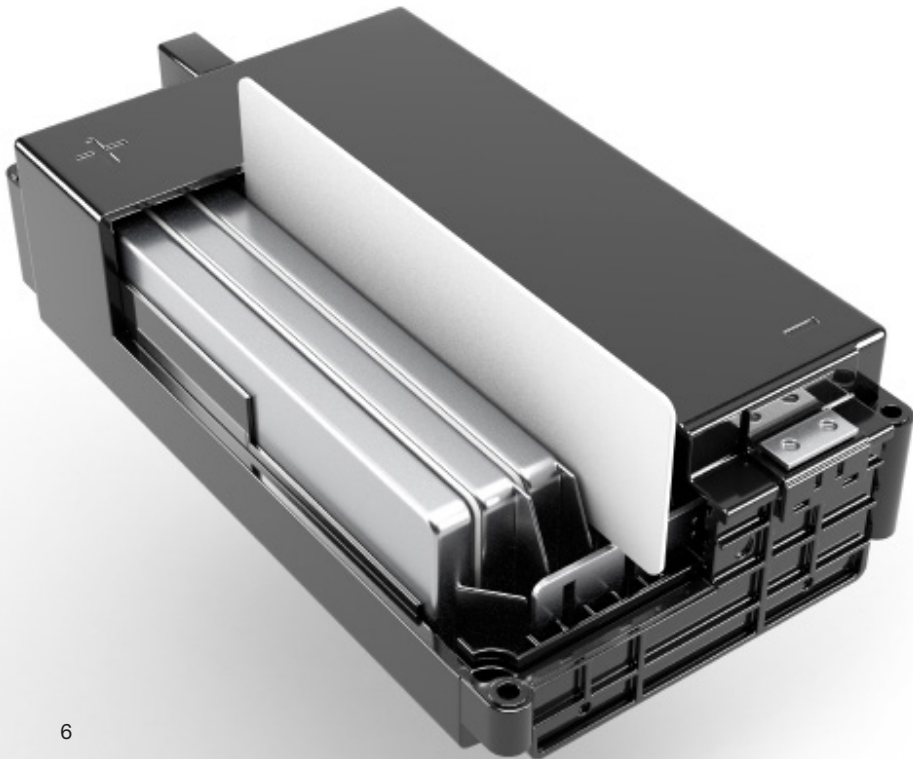
- Morgan is a global manufacturer of insulation blankets used in heat shield insulation systems.
- The ultra low thermal conductivity of Superwool® allows OEMs to reduce overall thickness and weight without compromising on performance or durability.
- Superwool is available in a blanket, paper and 3D formed shape.
- WDS® Microporous superior insulating properties allow OEMs to reduce the heatshield thickness by a factor of 3-5 over conventional needled mats.



Electric Vehicles

At Morgan we engineer, manufacturer and supply a range of technologically advanced, high temperature, lightweight and highly insulating ceramic fibre and microporous products.

EST™ (Energy Storage Technology) and WDS® Microporous products are designed to prevent or delay the propagation of thermal runaway in electric vehicle and energy storage applications.



Global collaboration

We collaborate with our customers to integrate EST products for thermal runaway protection in cell-cell, module-module, and pack protection systems.

Concerns for thermal management, space and weight can be mitigated with EST materials including:

- EST Compression Pads
- 3D Thermal Insulation Shapes
- Insulation Paper
- Flame Arresting Filter Paper
- WDS Microporous



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 gives us the background needed to bring ideas and material solutions into the reality of volume production.

Pouch cells with EST compression papers

Our EST Compression Papers are unique ceramic phase change materials (PCMs). Delivering superior thermal performance with an adjustable CFD curve designed to accommodate the cyclical expansion pouch and prismatic cells experience during normal operation.

These papers use Morgan's low biopersistent Superwool fibres, a unique binder system, and fillers to control the overall compression forces within targeted ranges at the beginning (BOL) and end-of-life (EOL) conditions.

The material is designed to displace foam inserts typically found between pouch and prismatic cells with a non-flammable UL94 V-0 rated substitute that acts as a thermal insulator for delay in propagation in case of a thermal event.

Application engineering

Extensive range of high temperature insulation products used to thermally manage battery and fuel cell 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

EST™ solutions

Our portfolio of products developed to manage thermal propagation in battery and energy storage applications, has been developed through partnering with industry leaders. We appreciate the complexities of new technologies and collaborate to ensure a superior solution, rather than adopt a 'one-size-fits-all' approach.

EST Papers

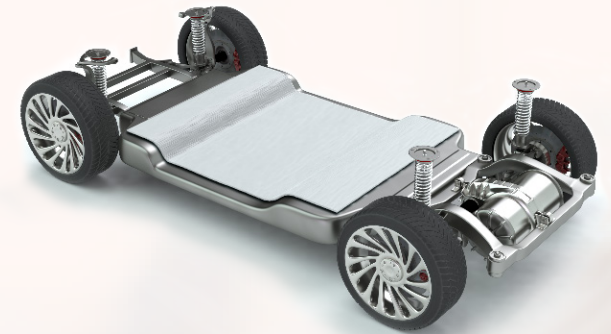
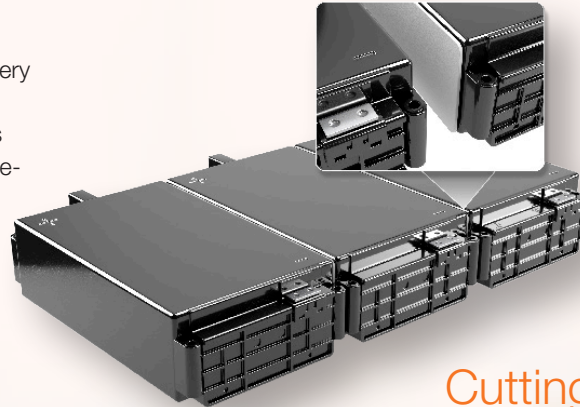
- Our EST Papers feature unique attributes to solve challenges with thermal energy absorption, hot gas evacuation and thermal resistance for Cell-Cell, Module-Module and Pack.

EST IC100 Coating

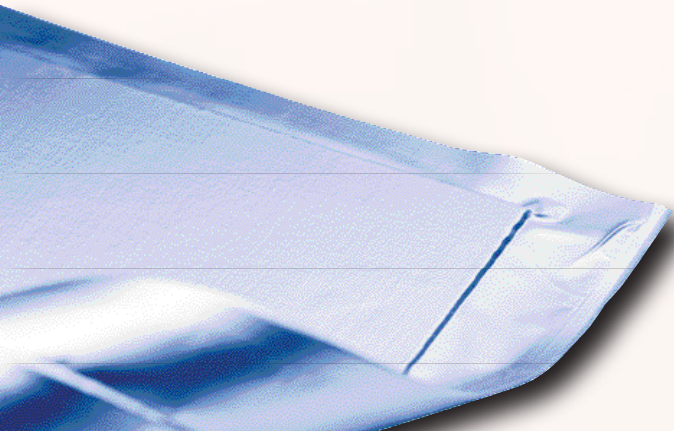
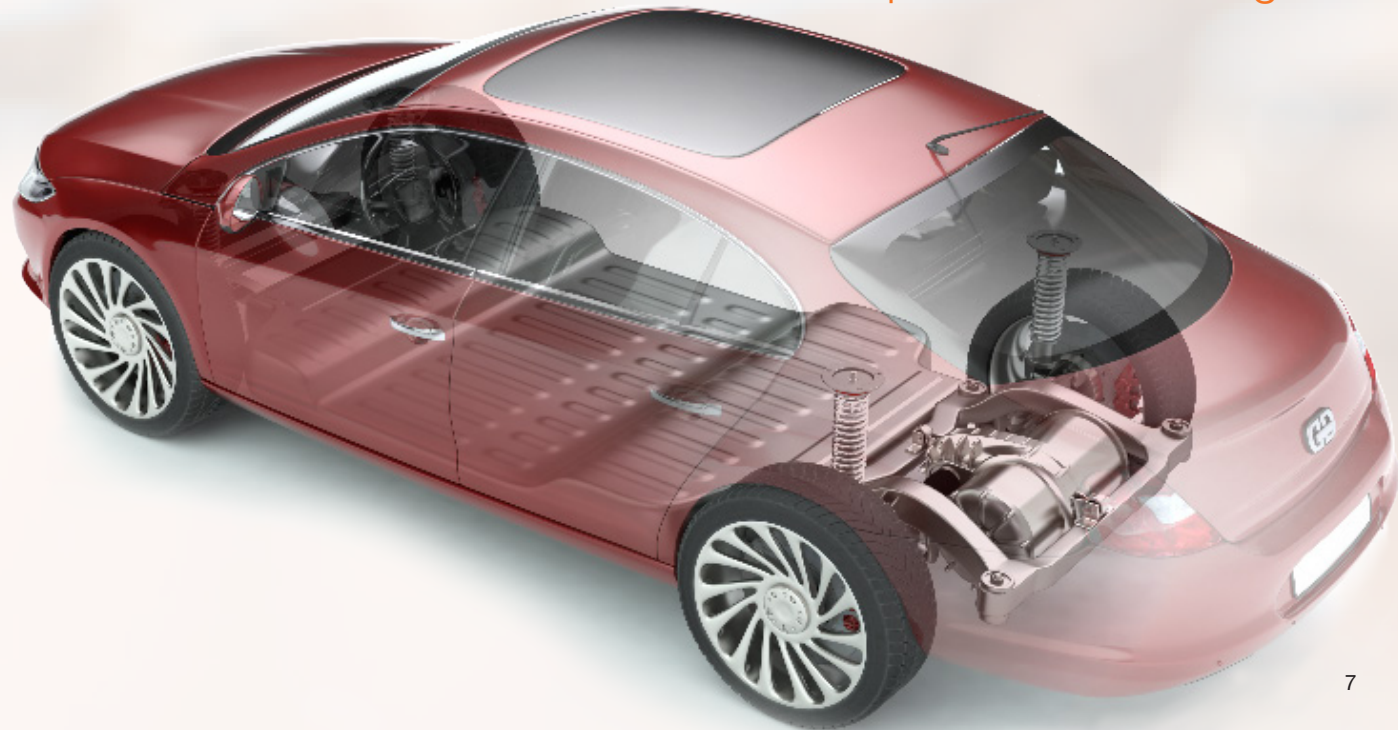
- EST IC100 Coating is a water-based thin-film intumescent fire protection coating. Its application characteristics offer good impact resistance and an aesthetic finish and is ideally suited for Module and Pack components.

WDS® Microporous and Vacupor®

- WDS Microporous and Vacupor solutions are lightweight, deliver exceptional thermal management performance and are sought out by OEMs and pack integrators helping to design systems that delay or prevent propagation in a thermal runaway event.



Cutting edge materials development, to solve complex thermal runaway and fire protection challenges



Emissions Control



We manufacture a range of advanced engineered fibres for use in emissions control devices. Our fibres play an integral role in the successful delivery of advanced vehicle emissions technologies, contributing to an improved environmental impact from the combustion engine.

We are proud to be a critical partner in the global effort to reduce CO₂, N₂O, particulate and other harmful emissions, as the world transitions to zero impact vehicles.



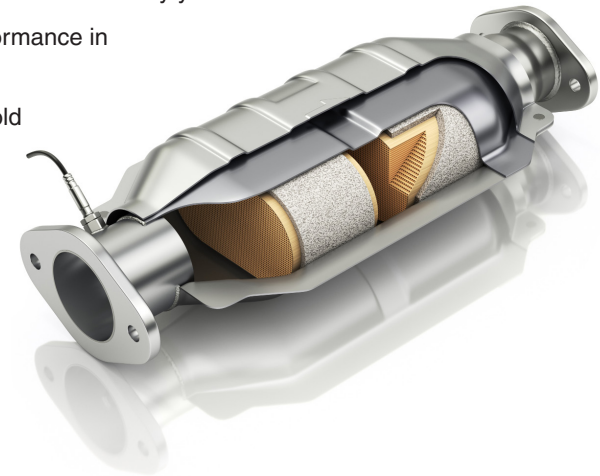
Advanced engineered fibres contain heat to reduce carbon dioxide and nitrous oxide emissions

Engineered fibre solutions

We provide customers with a range of ceramic fibres that are manufactured and modified in our specialised in-house processing, and meet exacting performance demands and specifications.

These advanced engineered fibres then become a key component in the manufacturing for catalytic converters, diesel particulate filters, gasoline particulate filters, diesel oxidation catalysts and other emission control devices.

- Advanced engineered fibres have been a part of (and evolved with) the increased performance demands of catalytic converters for more than twenty years
- Specialty fibres are designed to enhance the performance in diesel particulate and gasoline particulate filters
- Insulation components are designed to improve cold start emissions and contain the heat when and where it is needed
- Advanced engineered fibres are used to improve coating technologies and provide enhancements in devices that filter exhaust gases

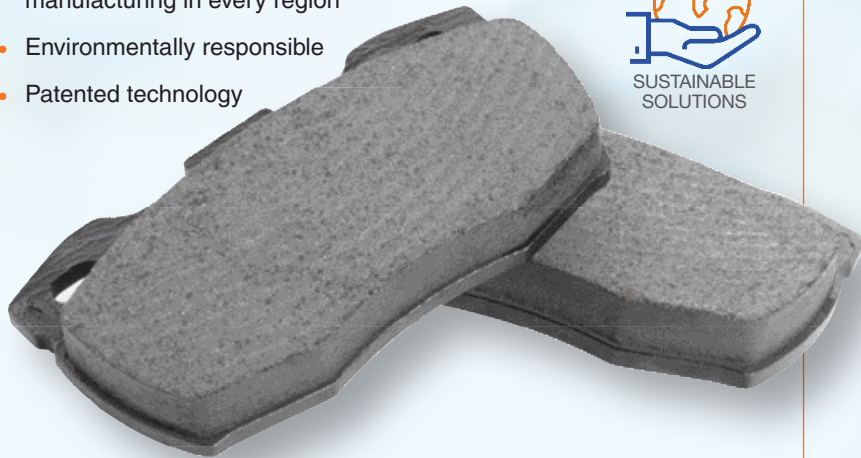


Friction

Our engineered fibres are blended into friction formulations producing stable friction over a wide range of temperatures, pressure, and speed. Our fibres won't cause black wheel dust or sacrifice long rotor and pad life for performance.

We have a proven track record for helping customers to improve products and respond to changing environmental concerns.

- Exonerated from carcinogen classification throughout the world
- Manufacturing globally to support automotive manufacturing in every region
- Environmentally responsible
- Patented technology



Formulations which produce stable friction without noise, no wheel dust, and improved pad and rotor life over a wide range of temperature, pressure, and speed

Customised fibre offerings

Global friction material manufacturers utilise our Superwool® Enfil™ family of fibres in OE and aftermarket formulations. Our customised fibre offerings are based on customer requirements and meet global health and safety regulations such as REACH.

Morgan's Superwool family of fibres yields the highest temperature stable structural matrix in friction formulations. Customised variations of Morgan's fibres provide outstanding value for all OE and after-market friction applications. Our Superwool Enfil fibres provide performance enhancements to semi-metallic, copper free, low steel pads, truck blocks, and lining materials. Morgan can assist in choosing the best material for your given application.

Superwool Enfil fibres for friction

We harness the ingenuity, passion and expertise of our employees to pursue increasingly advanced ceramic materials and applications which sets us apart.

- Supply intelligently engineered solutions to a wide variety of industries and market segments
- Integrated approach working with our customers incorporating Morgan's research, design, and global manufacturing expertise

Our Superwool low biopersistent fibre options for friction applications provide:

- Range of fibre index (reduce un-fibreised grains or shot)
- Fibre chemistry options for a wide temperature range



20+ Years Manufacturing Fibres for OE and Aftermarket

Today's largest global brake pad manufacturers utilise low biopersistent Superwool Enfil fibre options in OE and aftermarket formulations.

- Fibre length options for reinforcement and filler functionality
- Fibre chemistry options with thermal stability in excess of 1200°C (2192°F)
- Fibre index options to meet or exceed application performance requirements

Partnering with us

We are the partner of choice for the automotive sector, both in the conventionally powered and electric vehicles market. Working with us, 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-one automotive suppliers, developing competitive tailored solutions to meet the increasingly challenging demands of the sector. We are the forefront of technology helping manufacturers improve vehicle safety, performance, energy efficiency and comfort to create more fuel efficient, safer vehicles.

- **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, where 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

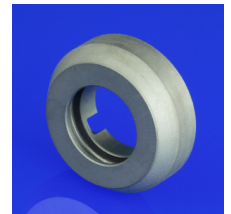
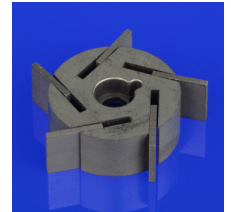
Morgan's ultrasonic sensors are used in personnel detection systems, enabling automotive manufactures to ensure that the airbags are deployed in the safest possible manner according to the passenger's position and meet stringent safety requirements.

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 Lithium-ion batteries, whilst also providing weight saving benefits.

Carbon bearings, vanes and rotors

Our Seals and Bearings business also produces carbon / graphite vanes and rotors offer 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...

Reduce our environmental impact



- 1 Our aspiration is to be a CO₂ net zero business by 2050. Our 2030 target is to reduce our scope 1 and scope 2 CO₂ 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).



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).



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

#WeAreMorgan

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 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 materials 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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