

# Wet Friction

EXPERIENCED. GLOBAL. INNOVATIVE.



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# Introduction to Carlisle Brake & Friction

Carlisle Brake & Friction is a globally recognized leader in the development and manufacture of highly innovative brake and friction system solutions to service a diverse range of industrial and off-highway applications. The comprehensive nature of Carlisle's brake system expertise includes hydraulic control products, brake assemblies, and wet and dry friction material for brake, clutch and transmission applications, all developed and manufactured under the Carlisle brand. Our full-system product offering supported by our industry-experienced staff of experts provides our customers with brake system solutions designed for safety and efficiency.

## Markets

Carlisle offers proven clutch and brake system designs for a wide range of markets, vehicle applications and equipment.



### CORE MARKETS DEFINED

#### Aircraft

#### Agriculture

- 2-wheel-drive tractors
- 4-wheel-drive tractors
- Combines
- Balers seeders

#### Industrial

- Material handling
- Transit systems
- Cranes
- Elevators

#### Waste/Refuse

- Wheel type tractors
- Refuse trucks
- Track type tractors

#### Construction

- Backhoe loaders
- Off-highway winches
- Compactors
- Articulated dump trucks
- Wheel loaders
- Pavers
- Excavators/Graders
- Bulldozers/Rollers
- Mobile cranes
- Dump trucks
- Wheeled tractor scrapers

#### Military

- Land vehicles
- Transports
- Tanks
- Assault vehicles
- Construction equipment

#### Mining

- Front-end loaders
- Haulage trucks
- Articulated dump trucks
- Winches
- Track type tractors

#### On-Highway/ Commercial Vehicle

- Class 1-6 Trucks & commercial vehicles
- Class 7-8 commercial trucks and trailers
- Emergency vehicles & school buses

#### Logging

- Skidders

## Global Manufacturing

Carlisle is committed to providing world-class manufacturing capabilities to a multi-national customer base and to support their continued global expansion. Carlisle operates manufacturing centers in the United States, China, Italy, the United Kingdom, Japan and India.

## Friction Material Portfolio

- Semi-Metallic
- Organic
- Metallic
- Paper/Wet
- Carbon-Carbon



# Why Choose Carlisle Brake & Friction

Through leveraging our unique, competitive combination of superior R&D and manufacturing capabilities, Carlisle has become a global leader in highly engineered, specialized vehicle brake actuation and friction material solutions. Serving a broad range of customers and industries with broad application knowledge, Carlisle's wet friction materials work in a wide range of severe duty applications providing superior performance and long service life, while enabling high energy and power density clutch and brake system designs.



Alessandro Gamba – Director of Friction R&D

## Carlisle Advantages

Since 1925, Carlisle has been driving friction innovation. We empower world-class original equipment manufacturers with products and services that yield a significant competitive advantage.

### CUSTOMER-CENTRIC

Dedicated to the success of our customers

### ADVANCED ENGINEERING

Extensive application knowledge, solutions provider

### GLOBAL CAPABILITIES

Engineering, manufacturing & sales support in Asia, the Americas, EMEA

### WORLD-CLASS QUALITY ASSURANCE

ISO 14001:2015, ISO 9001:2015, IATF 16949:2016

### OPERATIONAL EXCELLENCE

State of the art manufacturing processes

### SUPERIOR MATERIAL TECHNOLOGY

Broadest range of material competencies - friction material innovator

### EXPERIENCE

Reliable supplier to world-class OEMs for over 85 years

### FULL SYSTEM SOLUTIONS

From pedal to wheel

## Carlisle Wet Friction Application Advantages vs. Dry Friction Systems

- Longer life
- Immunity to dirt
- Dual-use as retarder
- High energy and power capability
- Less wear
- Lower noise and improved NVH behavior
- Smooth operation

## Benefits – Carlisle Wet Friction Materials

Carlisle offers a complete line of wet friction materials for all applications

- Higher coefficient of friction
- Higher energy absorption
- Stable coefficient of friction under extreme operating conditions
- Reduced system weight
- Improved shifting and braking characteristics
- Best in class life
- Reduced parasitic drag loss



# Application Specific Designs

## Carlisle Engineering Expertise

For the most demanding industrial applications, Carlisle delivers heavy-duty products that stand up to the world's toughest operating conditions. With Carlisle's experienced engineering resources and manufacturing capabilities, we can provide off-the-shelf or custom designed friction material solutions. Best of all, our brake and clutch wet friction material technologies are all backed by the engineering and application expertise of the Carlisle team.

## Carlisle Wet Friction Material Offering

Carlisle Wet Friction materials demonstrate considerable performance advantages compared to leading global competitive friction manufacturers. With a proven tolerance to high heat and pressure loading conditions, our friction materials resist wear in order to deliver long-lasting, consistent performance.



## Application Engineering and Material Recommendation Process

Application parameters such as vehicle weight, speed and duty cycle are analyzed and a material is selected that best fits the unitized operation parameters as indicated below:



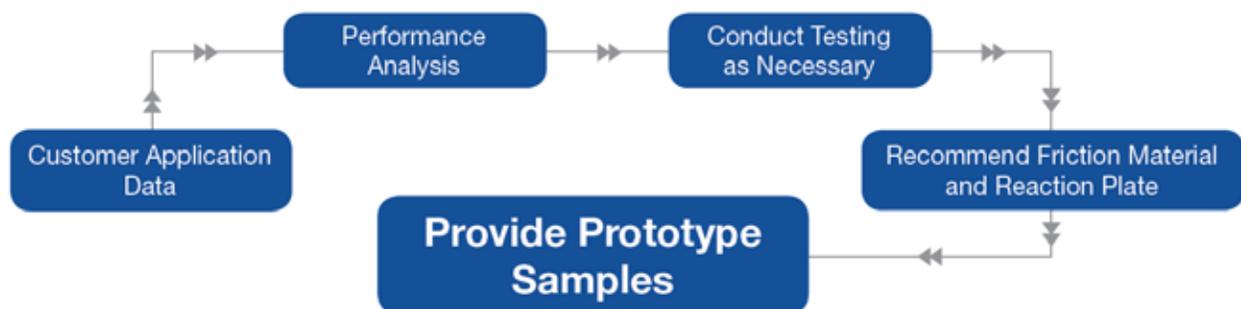
Operating Condition	Low	Medium	High
Apply Load - MPa	1	4	> 8
Energy Density - J/cm <sup>2</sup>	50	100	> 160
Oil Flow - l/min/cm <sup>2</sup>	0.003	0.009	> 0.018

In order to assist our customers in the design of their wet brake and transmission applications, Carlisle Brake and Friction R&D has the tools and knowledge to recommend materials and design parameters to the customer. Carlisle takes these parameters and searches our database of over forty years of dynamometer test results to

recommend the best friction material for the application. At the same time, Carlisle can assist the customer in the design of the brake, clutch, or transmission by recommending:

- Number of friction discs
- Reaction plate thickness
- Groove patterns
- OD and ID of the discs
- Apply loads

Carlisle also employs modeling software to better understand the oil flows and temperatures of the application. Carlisle can construct custom dynamometer testing to validate the customer's design and/or the friction material in the oil or oils specified. This laboratory evaluation paves the way to field testing where prototypes are delivered to the customer for final field validation before moving into production. Carlisle stands ready to assist customers in all aspects of friction system design from start to finish.



# Technical Data

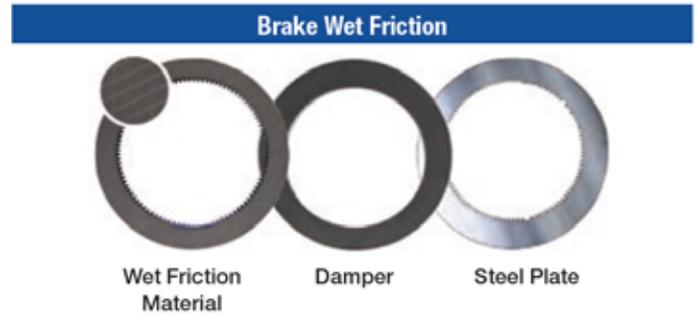
Carlisle wet friction product technologies sets the industry standard for durability, fitment, safety and quality. Each Carlisle friction material is designed to maximize equipment uptime, reduce annual maintenance costs and meet the harsh demands experienced by today's off-highway equipment applications. In order to ensure your equipment continues operating at maximum efficiency, choose the industry's leading OE friction products manufacturer, Carlisle Brake & Friction.

## Applications

### Brake Friction Material

Carlisle develops a variety of friction materials with high energy absorption capability and smooth engagement characteristics.

- High heat capability
- Ability to withstand high unit pressure loading
- Resists glazing from oil abuse
- Smooth engagement characteristics
- Comprehensive material technology coverage



### Transmission Friction Material

Carlisle develops a wide range of friction materials for powershift and countershift transmissions.

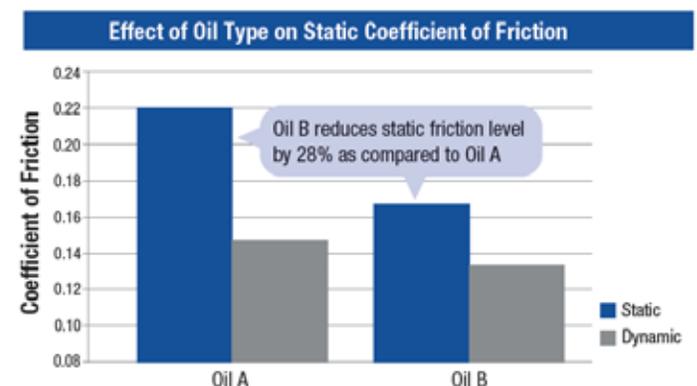
- Oil cooled friction applications
- High energy and power capacity
- High unit pressure
- High dynamic and static coefficients of friction
- Available in a range of thicknesses and oil groove patterns



## Oil Factors

The type of oil used will have a significant impact on friction material performance. Oil flow is critical to friction material life. Carlisle can assist customers in quantifying the effect of oil flow on their brake system or transmission performance.

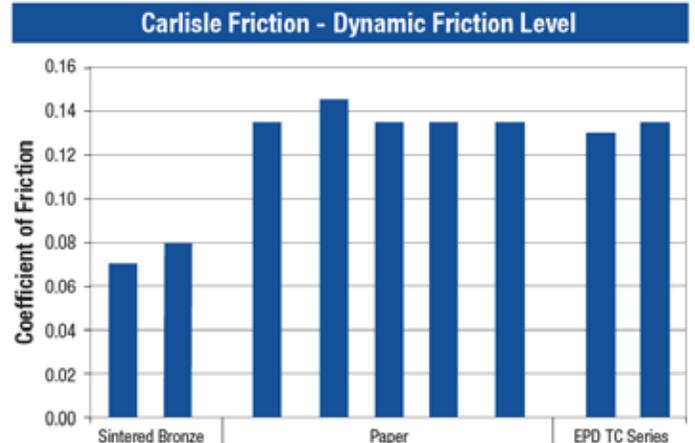
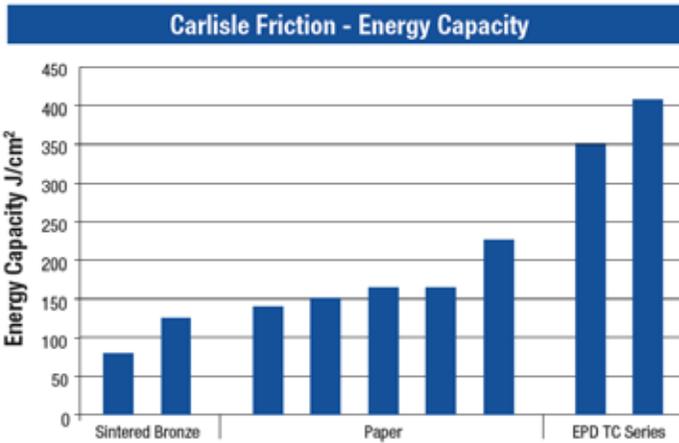
- Carlisle materials are tested and compatible with a large variety of oils
- Oil type can influence:
  - Static friction coefficients
  - Dynamic friction coefficients
  - Engagement characteristics
  - Performance under high energy or power conditions



# Performance Data

Carlisle is renowned for providing innovative friction solutions for Original Equipment Manufacturers (OEM's) around the globe. Our superior friction technology, advanced application engineering and progressive manufacturing techniques provide substantial benefits to our customers.

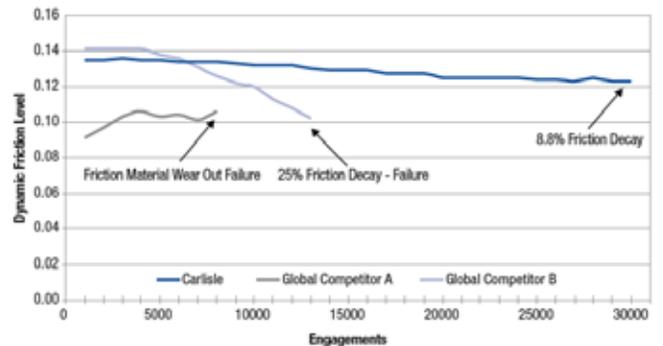
## Performance Data – Carlisle Wet Friction Materials



## Carlisle Wet Friction Glazing Test – Competitive Comparison Data

Carlisle's brake materials have been formulated to have superior glazing resistance. In abusive, high temperature conditions, Carlisle materials will maintain their stopping power compared to leading competitive materials.

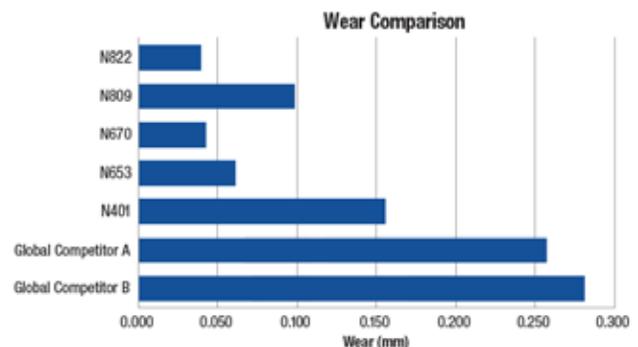
**Carlisle Wet Brake Glazing Test - Constant Power Input**  
Comparison of Carlisle, and Carlisle Global Competitor A and Global Competitor B Wet Brake Materials



**Glazing / Fade Resistance Under Heavy Braking**  
Carlisle offers superior resistance to glazing versus competitive materials.

## Carlisle Wet Friction Wear Comparison

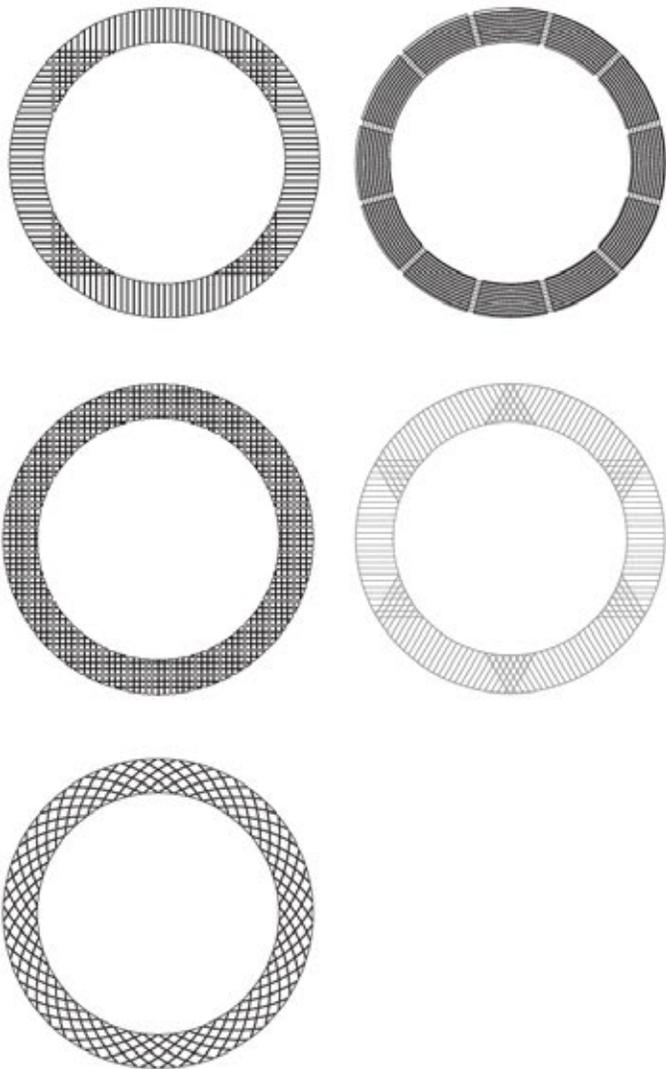
Carlisle materials offer best in class product life as compared to the competition. The decreased wear rate offers superior value to our customers by reducing downtime and operating costs.



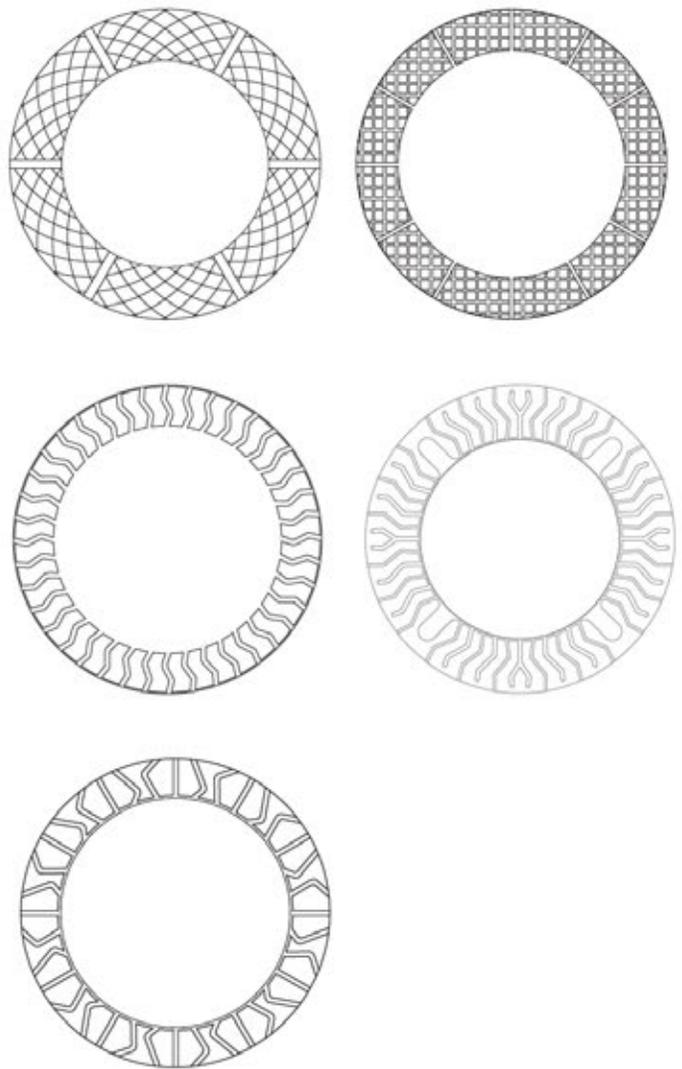
# Importance of Oil Groove Patterns

Grooving is important in facilitating cooling of the friction surface between engagement cycles. Keeping the friction surface properly cooled leads to stable coefficient of friction and avoids hot-spotting and distortion of the reaction plate. Cooling is necessary for efficient energy dissipation and to maintain a uniform heat distribution on the steel reaction plate. Groove patterns can also be used to reduce parasitic drag. Carlisle engineers can help select the correct groove pattern for your application.

## Conventional Cut/Pressed Grooves



## Formed Grooves and Combination Formed Cut/Pressed



# New Carlisle Application Highlights

## Tractors

Carlisle EPD21-468 Friction Material for a Power Take-off Clutch (PTO)

- Carlisle supplies friction products with EPD material for a PTO clutch application for tractors
- High energy capacity material
- Power dense clutch design



## Excavators

Carlisle N-1292 Friction Material for Wet Park Brakes – Integrated in Hydraulic Travel and Swing Motors

- Carlisle supplies friction products to a global manufacturer of hydraulic motors for use in wet park brakes integrated in hydraulic travel and swing motors in leading OEM excavators
- High static coefficient material that allows efficient packaging of integrated wet park brakes
- Pressed grooves to reduce parasitic drag when brake is not applied



## Gantry Crane

Carlisle Designed Wet Park Brake Using N-266 Friction Material

- Conversion of a dry brake to Carlisle wet friction spring applied hydraulic release brake system for improved performance
- High static coefficient material
- Pressed grooves to reduce parasitic drag when brake is not applied



The above data is presented for informational purposes and is representative of tests conducted to standard testing procedures, under controlled conditions in Carlisle Brake & Friction laboratories. This information implies no warranty or guarantee of performance, as actual values occurring in a particular system application may vary. To obtain additional information on material testing and performance, contact your Carlisle representative or email us at [sales@CarlisleCBF.com](mailto:sales@CarlisleCBF.com).

# Carlisle Wet Friction Material Offering

WET BRAKE MATERIALS							
Typical Applications	Friction Material	Energy Capacity	Max. Static Load, MPa	Max. Dynamic Load, MPa	Dynamic* Coefficient	Static* Coefficient	Comments
Static wet brakes such as hydraulic motors	N-1292	High	5.2	3.1	.12 to .16	.18 to .26	Very high static and breakaway coefficients
Steer clutches and brakes, PTO	N-266	Medium	8.4	5.6	.11 to .14	.15 to .19	Low cost and good energy, able to withstand high unit loading and tolerate rougher opposing surfaces
Wet parking brake	N-269	High	8.4	5.6	.11 to .15	.17 to .25	High static lock up and breakaway coefficients, good pressure capacity
Off highway mine truck brakes and loader brakes	N-360	Medium	3.9	2.5	.12 to .15	.15 to .19	Low cost and smooth engaging paper for low unit operating pressures
Inboard and outboard brakes for construction and agricultural vehicles	N-611	Medium to High	5.6	4.2	.11 to .15	.15 to .18	Good friction stability and heat resistance, low noise
Premium candidate for any brake application	N-653	Medium to High	7.0	5.6	.11 to .14	.14 to .16	Good friction stability, heat capacity and pressure capability, low noise
Brakes for loaders and off highway trucks	N-670	Medium to High	7.0	5.6	.11 to .14	.14 to .16	Good friction stability and heat capacity, ability to withstand high unit operating pressures
Brakes for loaders and military vehicle brakes and transmissions	TC Series	Very High	4.4	3.4	.11 to .14	.12 to .15	Woven carbon cloth material for high energy applications, 0.81 & 1.30 mm wafer thickness, low noise
Brakes for loaders and off highway trucks	N-809	Medium to High	5.6	4.5	.11 to .15	.10 to .16	Good friction stability, heat capacity and pressure capability

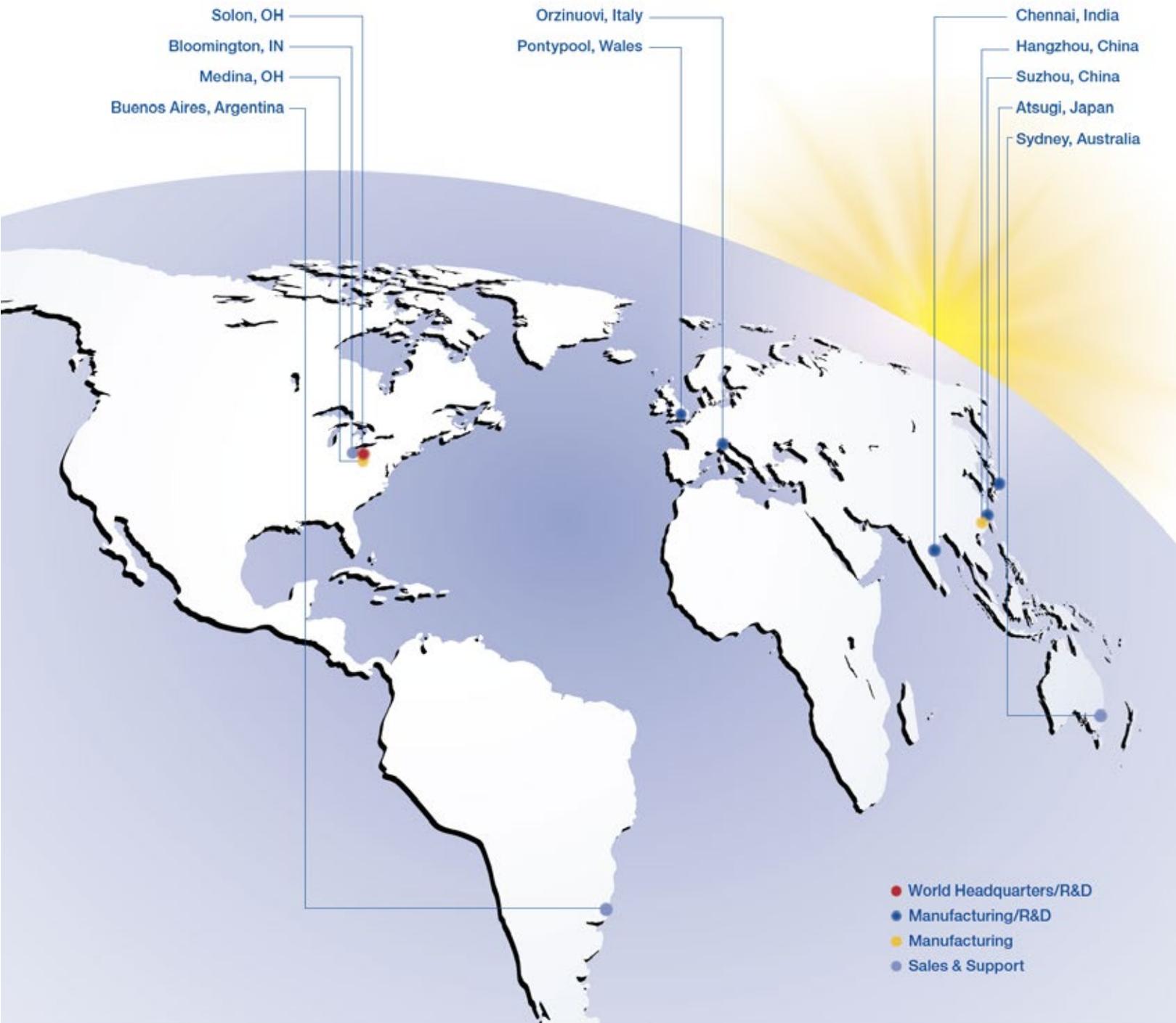
WET TRANSMISSION MATERIALS							
Typical Applications	Friction Material	Energy Capacity	Max. Static Load, MPa	Max. Dynamic Load, MPa	Dynamic* Coefficient	Static* Coefficient	Comments
Power shift transmissions, steer clutches and brakes, PTO	N-266	Medium	8.4	5.6	.11 to .14	.15 to .19	Low cost and good energy, able to withstand high unit loading and tolerate rougher opposing surfaces
Power shift and counter shaft transmissions	N-401	High	5.6	2.8	.11 to .14	.16 to .20	High energy capacity with a positive lock up, good durability
PTO clutches	N-420	Medium	5.5	2.8	.12 to .14	.15 to .17	Good engagement characteristics
Transmission material for high heat systems	N-670	Medium to High	7.0	5.6	.11 to .14	.14 to .16	Good friction stability and heat capacity, ability to withstand high unit operating pressures, smooth engaging
Loaders and military vehicle brakes and transmissions	TC Series	Very High	4.4	3.4	.11 to .14	.12 to .15	Woven carbon cloth material for high energy applications, 0.81 & 1.30 mm wafer thickness, low noise
Power shift and counter shaft transmissions	EPD	Very High	7.4	6.2	.12 to .15	.10 to .13	Very high energy capacity, can withstand higher unit operating pressures, good durability
Power shift and counter shaft transmissions	N-822	High	7.4	6.2	.12 to .16	.14 to .18	High energy capacity, can withstand higher unit operating pressures
Power shift and counter shaft transmissions	N-1198	High	7.4	6.2	.12 to .15	.13 to .16	High energy capacity, can withstand higher unit operating pressures, good engagement characteristics

\*Coefficient of friction oil dependent



**CARLISLE**  
BRAKE & FRICTION

# Carlisle Brake and Friction Worldwide Locations



To learn more about Carlisle's wet friction materials contact one of our sales offices or visit [www.carlislecbf.com](http://www.carlislecbf.com)

**United States**  
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Solon, OH 44139 USA  
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